# CIVIL ENGINEERING COLLEGE,

## SIBPUR.

VII
179

## CALENDAR FOR 1893.

Calcutta:

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1893.

# CONTENTS.


| | | Page. |
|---|---|---|
| 1. | Frontispiece. | |
| 2. | Almanac | 3 |
| 3. | Board of Visitors | 15 |
| 4. | College Staff | 16 |
| | **ENGINEER DEPARTMENT.** | |
| 5. | Engineer Department Rules | 17 |
| 6. | Syllabus of Instruction | 24 |
| 7. | Course of Study | 50 |
| 8. | Workshop Course | 51 |
| 9. | Annual Examination, 1st and 2nd years | 52 |
| 10. | F.E. Examination | 61 |
| 11. | L.E. and B.E. Examinations | 71 |
| 12. | List of Bachelors and Licentiates in Engineering of the Calcutta University | 86 |
| 13. | Scholarship-holders and Medallists | 90 |
| | **APPRENTICE DEPARTMENT.** | |
| 14. | Apprentice Department Rules | 92 |
| 15. | Course of Study | 98 |
| 16. | Leaving Report | 99 |
| 17. | Workshop Course | 100 |
| 18. | Admission Examination | 102 |
| 19. | Monthly Examination | 105 |
| 20. | Annual Examination | 124 |
| 21. | Final Examination | 133 |
| 22. | List of Passed Apprentices | 141 |
| | **DEPARTMENTAL EXAMINATION.** | |
| 23. | List of passed Assistant Engineers | 144 |
| 24. | Ditto Sub-Engineers | *ib.* |
| 25. | Ditto Overseers | 145 |
| 26. | Ditto Sub-Overseers | 148 |
| 27. | Miscellaneous Certificate-holders | 150 |
| | **ACCOUNTS.** | |
| 28. | Rules | 153 |
| 29. | List of Passed Accountants | 155 |
| 30. | Annual Report, 1891-92 | 168 |
| 31. | Annual Sports, 1892 | 177 |

# CIVIL ENGINEERING COLLEGE, SIBPUR, CALENDAR.

## ALMANAC, 1893.

## JANUARY 1893.

| Date. | Day of week. | General and Office. | Engineer Department. | Apprentice Department. |
|---|---|---|---|---|
| 1 | Sun. | 1st Sunday after Christmas. | | |
| 2 | M. | | | |
| 3 | T. | Christmas vacation ends. | | |
| 4 | W. | | | |
| 5 | Th. | | | |
| 6 | F. | | | |
| 7 | S. | | | |
| 8 | Sun. | 1st Sunday after Epiphany. | | |
| 9 | M. | | | Admission examination begins. |
| 10 | T. | | | |
| 11 | W. | | | |
| 12 | Th. | | | |
| 13 | F. | | | |
| 14 | S. | | | |
| 15 | Sun. | 2nd Sunday after Epiphany. | | |
| 16 | M. | Monthly fees due. | | |
| 17 | T. | | | |
| 18 | W. | | | |
| 19 | Th. | | | |
| 20 | F. | | | |
| 21 | S. | | | |
| 22 | Sun. | 3rd Sunday after Epiphany. | | |
| 23 | M. | Sripanchami, College holiday. | | |
| 24 | T. | | | |
| 25 | W. | | | |
| 26 | Th. | Monthly statement of fees due. | | |
| 27 | F. | | | |
| 28 | S. | | | |
| 29 | Sun. | Septuagesima. | | |
| 30 | M. | | 1st-year test examination in Science. | |
| 31 | T. | | Students return from Survey Camp. | |

## FEBRUARY 1893.

| Date. | Day of week. | General and Office. | Engineer Department. | Apprentice Department. |
|---|---|---|---|---|
| 1 | W. | | | |
| 2 | Th. | | | |
| 3 | F. | | | |
| 4 | S. | | | |
| 5 | Sun. | Sexagesima. | | |
| 6 | M. | | | |
| 7 | T. | | | |
| 8 | W. | | | |
| 9 | Th. | | | |
| 10 | F. | Annual sports. | | |
| 11 | S. | | | |
| 12 | Sun. | Quinquagesima. | | |
| 13 | M. | | | |
| 14 | T. | | | |
| 15 | W. | Monthly fees due. | | |
| 16 | Th. | | | |
| 17 | F. | | | |
| 18 | S. | | | |
| 19 | Sun. | 1st Sunday in Lent. | | |
| 20 | M. | | | |
| 21 | T. | | | |
| 22 | W. | | | |
| 23 | Th. | | | |
| 24 | F. | | | |
| 25 | S. | Monthly statement of fees due. | | |
| 26 | Sun. | 2nd Sunday in Lent. | | |
| 27 | M. | | 1st-year Mathematical examination. | |
| 28 | T. | | | |

## MARCH 1893.

| Date. | Day of week. | General and Office. | Engineer Department. | Apprentice Department. |
|---|---|---|---|---|
| 1 | W. | | | |
| 2 | Th. | Dol Jatra, College holiday. | | |
| 3 | F. | | | |
| 4 | S. | | | |
| 5 | Sun. | 3rd Sunday in Lent. | | |
| 6 | M. | | | Monthly examination begins. |
| 7 | T. | | | |
| 8 | W. | | | |
| 9 | Th. | | | |
| 10 | F. | | | |
| 11 | S. | | | |
| 12 | Sun. | 4th Sunday in Lent. | | |
| 13 | M. | | | |
| 14 | T. | | | |
| 15 | W. | Monthly fees due. | | |
| 16 | Th. | | | |
| 17 | F. | | | |
| 18 | S. | | | |
| 19 | Sun. | 5th Sunday in Lent. | | |
| 20 | M. | | | |
| 21 | T. | | | |
| 22 | W. | | | |
| 23 | Th. | | | |
| 24 | F. | | | |
| 25 | S. | Monthly statement of fees due. | | |
| 26 | Sun. | 6th Sunday in Lent. | | |
| 27 | M. | | 1st-year Mathematical examination. | |
| 28 | T. | | | |
| 29 | W. | | | |
| 30 | Th. | | | |
| 31 | F. | Good Friday. | | |

## APRIL 1893.

| Date. | Day of Week. | General and Office. | Engineer Department. | Apprentice Department. |
|---|---|---|---|---|
| 1 | S. | College holiday. | | |
| 2 | Sun. | Easter Day. | | |
| 3 | M. | | | Monthly examination begins. |
| 4 | T. | | | |
| 5 | W. | Accountant examination to be advertised in *Calcutta Gazette*. | | |
| 6 | Th. | | | |
| 7 | F. | | | |
| 8 | S. | Accountant examination to be advertised in *India Gazette*. | | |
| 9 | Sun. | 1st Sunday after Easter. | | |
| 10 | M. | | Last date for receiving application for F.E. examination. | |
| 11 | T. | | | |
| 12 | W. | Chaitra Sankranti, College holiday | | |
| 13 | Th. | | | |
| 14 | F. | Detailed statement of establishment due, | | |
| 15 | S. | Monthly fees due. | | |
| 16 | Sun. | 2nd Sunday after Easter. | | |
| 17 | M. | | | |
| 18 | T. | | | |
| 19 | W. | | | |
| 20 | Th. | | | |
| 21 | F. | | | |
| 22 | S. | Advertise admission to Engineer Department in *India Gazette*. | | |
| 23 | Sun. | 3rd Sunday after Easter. | | |
| 24 | M. | | F.E. examination begins. | |
| 25 | T. | Annual report due. | | |
| 26 | W. | Monthly statement of fees due. | | |
| 27 | Th. | | | |
| 28 | F. | | | |
| 29 | S. | Indent for chemical apparatus due. | | |
| 30 | Sun. | 4th Sunday after Easter. | | |

## MAY 1893.

| Date. | Day of week. | General and Office. | Engineer Department. | Apprentice Department. |
|---|---|---|---|---|
| 1 | M. | Report of surveying instruments for repair due. | | Monthly examination begins. |
| 2 | T. | | | |
| 3 | W. | | | |
| 4 | Th. | | | |
| 5 | F. | Last day for receiving applications for admission to Accountant examination. | | |
| 6 | S. | | | |
| 7 | Sun. | 5th Sunday after Easter. | | |
| 8 | M. | | | |
| 9 | T. | | | |
| 10 | W. | | Practical examination of 1st and 2nd years begins. | |
| 11 | Th. | | | |
| 12 | F. | | | |
| 13 | S. | | | |
| 14 | Sun. | Sunday after Ascension. | | |
| 15 | M. | Monthly fees due. | | |
| 16 | T. | | | |
| 17 | W. | | | |
| 18 | Th. | | | |
| 19 | F. | | | |
| 20 | S. | | | |
| 21 | Sun. | Whitsunday. | | |
| 22 | M. | | Last day for receiving applications for admission. | |
| 23 | T. | | | |
| 24 | W. | Queen's Birthday. | | |
| 25 | Th. | Dasahara, College holiday. | | |
| 26 | F. | | Annual examination, 1st and 2nd years, begins. | |
| 27 | S. | | | |
| 28 | Sun. | Trinity Sunday. | | |
| 29 | M. | | | |
| 30 | T. | | | |
| 31 | W. | | | |

# JUNE 1893.

| Date. | Day of week. | General and Office. | Engineer Department. | Apprentice Department. |
|---|---|---|---|---|
| 1 | Th. | Indent for stationery due. | | Monthly examination begins. |
| 2 | F. | | | |
| 3 | S. | | | |
| 4 | Sun. | 1st Sunday after Trinity. | | |
| 5 | M. | 4th grade Accountant examination begins. | Opening of Session. New students join. | |
| 6 | T. | | | |
| 7 | W. | | | |
| 8 | Th. | | | |
| 9 | F. | | | |
| 10 | S. | | | |
| 11 | Sun. | 2nd Sunday after Trinity. | | |
| 12 | M. | | | |
| 13 | T. | | | |
| 14 | W. | | | |
| 15 | Th | Monthly fees due. | | |
| 16 | F. | | | |
| 17 | S. | | | |
| 18 | Sun. | 3rd Sunday after Trinity. | | |
| 19 | M. | | | |
| 20 | T. | | | |
| 21 | W. | | | |
| 22 | Th. | | | |
| 23 | F. | | | |
| 24 | S. | | | |
| 25 | Sun. | 4th Sunday after Trinity. | | |
| 26 | M. | Monthly statement of fees due. | Last date for receiving applications for L.E. and B.E. examinations. | |
| 27 | T. | Indent for forms due. | | |
| 28 | W. | | | |
| 29 | Th. | | | |
| 30 | F. | | | |

# JULY 1893.

| Date. | Day of week. | General and Office. | Engineer Department. | Apprentice Department. |
|---|---|---|---|---|
| 1 | S. | | | |
| 2 | Sun. | 5th Sunday after Trinity. | | |
| 3 | M. | | | Monthly examination begins. |
| 4 | T. | | | |
| 5 | W. | | | |
| 6 | Th. | | | |
| 7 | F. | | | |
| 8 | S. | | | |
| 9 | Sun. | 6th Sunday after Trinity. | | |
| 10 | M. | | L.E. and B.E. examination begins. | |
| 11 | T. | | | |
| 12 | W. | | | Final examination, 4th year, begins. |
| 13 | Th. | | | |
| 14 | F. | | | |
| 15 | S. | Monthly fees due. | | |
| 16 | Sun. | 7th Sunday after Trinity. | | |
| 17 | M. | | | Practical examination, 1st, 2nd, and 3rd years, begins. |
| 18 | T. | | | |
| 19 | W. | | | |
| 20 | Th. | | | |
| 21 | F. | | | |
| 22 | S. | | | |
| 23 | Sun. | 8th Sunday after Trinity. | | |
| 24 | M. | | | |
| 25 | T. | | | |
| 26 | W. | Monthly statement of fees due. | | Final practical examination, 4th year, begins. |
| 27 | Th. | | | |
| 28 | F. | | | |
| 29 | S. | | | |
| 30 | Sun. | 9th Sunday after Trinity. | | |
| 31 | M. | Budget estimate due. | | Annual examination, 1st, 2nd, and 3rd years, begins. |

# AUGUST 1893.

| Date. | Day of week. | General and Office. | Engineer Department. | Apprentice Department. |
|---|---|---|---|---|
| 1 | T. | | | |
| 2 | W. | | | |
| 3 | Th. | | | |
| 4 | F. | | | |
| 5 | S. | | | |
| 6 | Sun. | 10th Sunday after Trinity. | | |
| 7 | M. | | | |
| 8 | T. | | | |
| 9 | W. | | | |
| 10 | Th. | Monthly fees for August and September due. | | |
| 11 | F. | | | |
| 12 | S. | | | |
| 13 | Sun. | 11th Sunday after Trinity. | | |
| 14 | M. | College closes for long vacation. | | |
| 15 | T. | | | |
| 16 | W. | | | |
| 17 | Th. | | | |
| 18 | F. | | | |
| 19 | S. | | | |
| 20 | Sun. | 12th Sunday after Trinity. | | |
| 21 | M. | | | |
| 22 | T. | | | |
| 23 | W. | | | |
| 24 | Th. | | | |
| 25 | F. | Monthly statement of fees due. | | |
| 26 | S. | | | |
| 27 | Sun. | 13th Sunday after Trinity. | | |
| 28 | M. | | | |
| 29 | T. | | | |
| 30 | W. | | | |
| 31 | Th. | | | |

## SEPTEMBER 1893.

| Date. | Day of week. | General and Office. | Engineer Department. | Apprentice Department. |
|---|---|---|---|---|
| 1 | F. | | | |
| 2 | S. | | | |
| 3 | Sun. | 14th Sunday after Trinity. | | |
| 4 | M. | | | |
| 5 | T. | | | |
| 6 | W. | | | |
| 7 | Th. | | | |
| 8 | F. | | | |
| 9 | S. | | | |
| 10 | Sun. | 15th Sunday after Trinity. | | |
| 11 | M. | | | |
| 12 | T. | | | |
| 13 | W. | | | |
| 14 | Th. | | | |
| 15 | F. | | | |
| 16 | S. | | | |
| 17 | Sun. | 16th Sunday after Trinity. | | |
| 18 | M. | | | |
| 19 | T. | | | |
| 20 | W. | | | |
| 21 | Th. | | | |
| 22 | F. | | | |
| 23 | S. | Fatiha dawazdaham holiday. | | |
| 24 | Sun. | 17th Sunday after Trinity. | | |
| 25 | M. | Monthly statement of fees due. | | |
| 26 | T. | | | |
| 27 | W. | | | |
| 28 | Th. | | | |
| 29 | F. | | | |
| 30 | S. | | | |

# OCTOBER 1893.

| Date. | Day of week. | General and Office. | Engineer Department. | Apprentice Department. |
|---|---|---|---|---|
| 1 | Sun. | 18th Sunday after Trinity. | | |
| 2 | M. | | | |
| 3 | T. | | | |
| 4 | W. | | | |
| 5 | Th. | | | |
| 6 | F. | | | |
| 7 | S. | | | |
| 8 | Sun. | 19th Sunday after Trinity. | | |
| 9 | M. | Mahalaya holiday. | | |
| 10 | T. | | | |
| 11 | W. | | | |
| 12 | Th. | | | |
| 13 | F. | | | |
| 14 | S. | | | |
| 15 | Sun. | 20th Sunday after Trinity. | | |
| 16 | M. | Durga Pujah holidays. | | |
| 17 | T. | | | |
| 18 | W. | | | |
| 19 | Th. | | | |
| 20 | F. | | | |
| 21 | S. | | | |
| 22 | Sun. | 21st Sunday after Trinity. | | |
| 23 | M. | | | |
| 24 | T. | Lakhim Puja. | | |
| 25 | W. | | | |
| 26 | Th. | | | |
| 27 | F. | Monthly statement of fees due. | | |
| 28 | S. | | | |
| 29 | Sun. | 22nd Sunday after Trinity. | | |
| 30 | M. | | | |
| 31 | T. | | | |

# NOVEMBER 1893.

| Date. | Day of week. | General and Office. | Engineer Department. | Apprentice Department. |
|---|---|---|---|---|
| 1 | W. | | | |
| 2 | Th. | | | |
| 3 | F. | | | |
| 4 | S. | | | |
| 5 | Sun. | 23rd Sunday after Trinity. | | |
| 6 | M. | College re-opens after long vacation. | | |
| 7 | T. | | | |
| 8 | W. | Kali Puja. | | |
| 9 | Th. | | | |
| 10 | F. | | | |
| 11 | S. | | | |
| 12 | Sun. | 24th Sunday after Trinity. | | |
| 13 | M. | | Surveying for 1st year begins. | Surveying for 2nd, 3rd, and 4th years begins. |
| 14 | T. | | | |
| 15 | W. | Fees for October and November due. Advertise admission examination to Apprentice Department in *Calcutta Gazette*. | | |
| 16 | Th. | | Surveying for 2nd year begins. | |
| 17 | F. | | | |
| 18 | S. | Advertise admission examination to Apprentice Department in *India Gazette*. Jagadhatri Puja holiday. | | |
| 19 | Sun. | 25th Sunday after Trinity. | | |
| 20 | M. | | | |
| 21 | T. | | | |
| 22 | W. | | | |
| 23 | Th. | | Surveying for 3rd year begins. | |
| 24 | F. | | | |
| 25 | S. | | | |
| 26 | Sun. | 26th Sunday after Trinity. | | |
| 27 | M. | | | |
| 28 | T. | | | |
| 29 | W. | | | |
| 30 | Th. | | | |

## DECEMBER 1893.

| Date. | Day of week. | General and Office. | Engineer Department. | Apprentice Department. |
|---|---|---|---|---|
| 1 | F. | | | |
| 2 | S. | | | |
| 3 | Sun. | 1st Sunday in Advent. | | |
| 4 | M. | | | |
| 5 | T. | | | |
| 6 | W. | | | |
| 7 | Th. | | | |
| 8 | F. | | | |
| 9 | S. | | | |
| 10 | Sun. | 2nd Sunday in Advent. | | |
| 11 | M. | | Annual tour of senior students begins. | |
| 12 | T. | | | |
| 13 | W. | | | |
| 14 | Th. | | | |
| 15 | F. | Monthly fees due. | | |
| 16 | S. | | | |
| 17 | Sun. | 3rd Sunday in Advent. | | |
| 18 | M. | | | |
| 19 | T. | | | |
| 20 | W. | | | |
| 21 | Th. | Last day for receiving applications for permission to appear at admission examination. | | |
| 22 | F. | Christmas vacation begins. | | |
| 23 | S. | | | |
| 24 | Sun. | 4th Sunday in Advent. | | |
| 25 | M. | Christmas Day. | | |
| 26 | T. | | | |
| 27 | W. | | | |
| 28 | Th. | Monthly statement of fees due. | | |
| 29 | F. | | | |
| 30 | S. | | | |
| 31 | Sun. | 1st Sunday after after Christmas. | | |

# CIVIL ENGINEERING COLLEGE, SIBPUR.

## BOARD OF VISITORS.

1. Secretary to the Government of Bengal, Public Works Department.
2. Director of Public Instruction, Bengal.
3. Joint-Secretary, Government of Bengal, Public Works Department.
4. Civil Surgeon, Howrah.
5. Inspector of Schools, Presidency Circle.
6. Principal, Civil Engineering College, Seebpore.
7. Executive Engineer, Calcutta Workshops Division.
8. Magistrate of Howrah.
9. Superintendent of Works, Calcutta.

*Ex-officio.*

10. Babu Kunja Lal Banerjea.
11. W. H. Ryland, Esq.
12. Babu Bhudev Mukerjea.
13. Mahamahopadhyay Mahes Chandra Nyaratna, C.I.E.
14. The Lord Bishop of Calcutta.
15. Maharajah Sir Jotendra Mohan Tagore, K.C.S.I.
16. Brigade-Surgeon G. King, M.B., L.LD., F.R.S., C.I.E.
17. F. J. E. Spring, Esq.

# COLLEGE STAFF.

Principal and Professor of Engineering ... J. S. Slater.

## Engineer Department.

| | |
|---|---|
| Professor of Mathematics ... ... | A. Macdonell, M.A. |
| Officiating Professor of Surveying ... | B. Heaton. |
| Professor of Physical Science ... | P. Brühl. |
| Professor of Drawing ... ... | J. T. Bartlett (on furlough). |
| Offg. ditto ... ... | Dwarka Nath Dutt. |
| Assistant to Professor of Physical Science | Upendra Nath Mitra. |

## Apprentice Department.

| | |
|---|---|
| Head Master and Lecturer on Physical Science ... ... ... | R. W. F. Shaw, M.A. |
| Teacher ... ... ... | Dwarka Nath Dutt (on deputation). |
| Officiating Teacher ... ... | Surendra Nath Bhattacharjya, B.E. |
| Teacher ... ... ... | Surendra Kumar Bose, B.C.E. |
| Temporary Teacher ... ... | Hari Charan Mukerjee, L.E. |

## Workshops.

| | |
|---|---|
| Executive Engineer, Calcutta Workshops Division ... ... ... | C. P. Warde, L.C.E. |
| Foreman Instructor ... ... | W. G. Lawrence. |

Ten native instructors.

## Hostels.

| | |
|---|---|
| Superintendent of European Mess ... | R. W. F. Shaw, M.A. |
| Ditto Native Mess ... | Ashutosh Ganguli. |

## Medical Officer.

Assistant Surgeon Dino Bandhu Dutt, Honorary Assistant Surgeon to His Excellency the Viceroy.

# CIVIL ENGINEERING COLLEGE, SIBPUR.

## ENGINEER DEPARTMENT.

### GENERAL RULES.

1. The College is under the general supervision of a Board of Visitors appointed by the Government.

2. The Principal of the College is charged with the general control of the institution, including the regulation of the course of study, the supervision of the mess and other domestic arrangements, and the maintenance of discipline; and he will from time to time issue such rules as may be necessary to secure those objects. The workshops are under the control of the Superintendent, and the students while at work in them will be under his orders, but all breaches of discipline will be reported by him to the Principal.

### Rules for Admission.

3. For admission to the Engineer Department a student must have passed one of the following tests:—

(1) The Entrance Examination of the Calcutta University, and in English and Mathematics must have obtained at least 40 and 50 per cent. respectively of the marks allotted to those subjects. The candidate's age must be under 19 years.

(2) The F.A. Examination of the Calcutta University. The candidate's age must be under 21 years.

(3) The B.A. Examination in the B. course. The candidate's age must be under 23 years. (These students are admitted direct into the second-year class.)

4. Every candidate for admission to this Department must apply in writing to the Principal not later than the 25th May, furnishing satisfactory proof of his having passed the Entrance Examination.

5. Every applicant, before admission to the College, will be examined by the College Surgeon as to his physical strength, fitness for manual labour, and eyesight. If this officer's report is unsatisfactory, the applicant will not be admitted.

6. Each student received into the College will be required to pay an admission fee of Rs. 10.

7. The session begins on the first Monday in June. All students are required to join the College on that day. Any student prevented by sickness from attending on the opening day must produce a certificate to that effect from a Civil or Assistant Surgeon, failing which he will be liable to a fine not exceeding Rs. 10. No student will be admitted or re-admitted to the College after the close of the month of June, except by special order of the Director of Public Instruction. This permission will only be given under exceptional circumstances.

COURSE OF INSTRUCTION.

8. The course of instruction in the Engineer class will extend over five years, during the first four of which the instruction will be both theoretical and practical. The last year will be spent entirely in practical work. For details of the course of study, *see* Syllabus attached.

9. The students of the Engineer Department will be divided into sections—A, Civil; B, Mechanical.* Both sections will attend the same lectures for the first three years, and the students will then present themselves at the first examination in Engineering of the Calcutta University, which is held in the month of May. After passing this examination the sections will separate, the students of each section attending only those lectures which will enable them to qualify at the examinations of the Calcutta University for degrees or licenses in Civil or Mechanical Engineering.

This section has not yet been established.

10. After the expiration of one year from the date of passing the first examination in Engineering, students will be qualified to appear at the University examination for degrees or licenses.

*Extract from the* "Calcutta Gazette" *of the* 16*th March* 1887, *page* 79, *Part IB.*

A candidate for employment as District Engineer must be qualified in one of the manners following, that is to say, he must—

(5) Hold the degree of Bachelor of Engineering or be Licentiate of Engineering of the Calcutta University, and have been employed on engineering works for not less than five years, exclusive of any time spent on apprenticeship, and hold satisfactory certificates of good conduct and efficiency during such employment.

11. After qualifying for a University degree or license in Engineering, every student will be employed for one year on practical work only, either in the workshops or on works in progress. On completing this course to the satisfaction of the College authorities, he will be entitled to receive the final College certificate.

12. A student failing at either the first or the second University examination may, with the sanction of the Director of Public Instruction, on the recommendation of the College authorities, be permitted to attend the College for one year more in order to re-appear at the examination; but no student will be allowed to attend the College course after the expiration of five years from admission. A student failing at the second examination will be allowed to attend the practical course for one year. The final College certificate shall state whether the student has or has not taken the University degree in Engineering and in which branch, and whether he has or has not completed the course of practical work to the satisfaction of the College authorities. A College certificate gives the holder no claim to a Government appointment.

13. Students will attend daily in the class-room and in the workshops in accordance with the College time-table. The hours of

work may vary with the seasons of the year. The fourth-year class is excused from work in the shops.

14. The rules for the transfer of Engineer students to the Apprentice Department are as follows:—

(*a*) First and second-year Engineer students may apply for transfer to the Apprentice Department immediately after the result of their annual examination is published. Transfers cannot be made at any other time of the year.

(*b*) No student can be transferred who has failed in the practical examination immediately preceding his application for transfer.

(*c*) First-year students may be admitted to the first year, and second-year students to the second-year class of the Apprentice Department: these students must pass the annual examination of the class to which they are transferred in both theory and practice before they can be promoted to a higher class.

(*d*) No student who has once been transferred to the Apprentice Department can be readmitted to the Engineer Department.

(*e*) The age of a student on transfer must be below 17 years and 4 months, if transferred to the first-year class, and below 18 years and 4 months if to the second-year class of the Apprentice Department.

15. There will be a long vacation from about the middle of August to the end of October. Every student must leave the College during this vacation, and parents or guardians must satisfy the Principal, before their sons or wards can be admitted, that they are able to conform to this rule. The period from the middle of November to the end of January will be occupied in survey work.

## Tuition Fees.

16. The tuition-fee for students of the Engineer class is Rs. 8 a month for each month of the year, vacation included.

## Scholarships.

17. For the present, one junior scholarship of the value of Rs. 20 a month, three of Rs. 15 a month, and six of Rs. 10, tenable for two years, will be given annually to students entering the first-year Engineer class who do not already hold University scholarships. The scholarships will be awarded by the Director of Public Instruction on the last day of June to the following classes of students in order:—(1) B.A's. who have taken up the B. course; (2) F.A. candidates;* (3) Entrance candidates according to the number of marks gained in English and Mathematics jointly.

18. Senior scholarships of the same number and value will be competed for at the annual examination held in May for the promotion of students from the second to the third-year class.

* Except those who passed in the 3rd Division.

### Scholarships.

19. The number of College scholarships awarded, whether junior or senior, will in no case exceed one-half of the number of candidates for them.

20. Two scholarships of Rs. 10 a month each, tenable for one year, called Forbes' scholarships, will be awarded on the result of the first examination in Engineering of the Calcutta University. A Forbes' scholar, unless he also holds a College scholarship, will be exempted from paying the tuition-fee of Rs. 8 a month.

21. On the result of the University Examination for degrees and licenses, two graduate scholarships of Rs. 100 each and six of Rs. 50 each will, for the present, be awarded to those students who pass the best examination. The scholarships of Rs. 100 a month will be reserved for holders of the B.E. degree, *i.e.*, those who have passed the F.A. examination. All the eight scholarships will be tenable for one year, provided that the students are continuously employed during that period in practical work under the supervision of the Public Works Department, and to the satisfaction of those under whose orders they may be placed.

22. A gold medal will be awarded to the student who gains the highest marks in mathematics at the examination for the B.E. degree. The holder of this medal will be styled the "Ambica Churn Chaudhuri Medalist."

23. All scholarships will be liable to forfeiture in case of misconduct or of neglect of work in class or in the field, or of failure to pass any prescribed examination.

### Standing Orders for Students.

24. Except with the special sanction of the Principal, students of the Engineer Department will be required to reside on the College premises, so far as the accommodation will permit, at a rent to be fixed from time to time by the Government. The present rate is Rs. 2 a month for both European and native students.* This charge will be levied all the year round, except during any period in which the student may be in camp.

25. Each resident student must provide his own clothing and bedding and a camp bedstead. No furniture may be brought into the College without special permission.

### *European Mess.*

26. Every resident European student will join the European mess. A charge of Rs. 20 a month will be made to defray the cost of messing. During the vacation, reckoned at 2½ months, each European student will be required to pay monthly, in addition to Rs. 2 for house-rent, a contribution of Rs. 2 towards the cost of maintaining mess-servants.†

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* Native students now in the College and paying Re. 1 a month house-rent will continue to pay this sum only.

† European students have, at their own request, established a private mess, the cost of which is about Rs. 30 per mensem.

27. On joining the mess, every student will pay an entrance fee of Rs. 10 to the mess fund to provide for the cost of crockery, knives and forks, table-linen, &c. A list of breakages and other damage done will be prepared monthly, and each student will be required to pay, by the 15th of the following month, an equal share of the cost. On leaving the mess, if a student has paid all demands, his entrance fee will be returned to him; otherwise it will be forfeited to the mess fund.

28. For students joining the European mess the following table shows the annual cost of living at the College, the term being reckoned as nine months and a half and the vacation as two months and a half of the year:—

| | Tuition per mensem. | Board per mensem. | House-rent per mensem. | Total monthly charges. | Total per annum. | Grand total. |
|---|---|---|---|---|---|---|
| | Rs. | Rs. | Rs. | Rs. | Rs. | Rs. |
| Term ... ... ... ... | 8 | 20 | 2 | 30 | 285 | 315 |
| Vacation ... ... ... | 8 | 2 | 2 | 12 | 30 | |

*Native Mess.*

29. Hindu students residing on the College premises must ordinarily join the College mess for natives, and must abide by the rules sanctioned by the Principal for the management of their mess. Each student on joining the mess will be required to deposit "caution-money" to the amount of Rs. 5, which will be ultimately returned to the student if he has not rendered himself liable to the forfeiture of the whole or any part of it.

30. A charge of Rs. 7 a month will be made to those joining the native mess. During the vacation of two months every member of the mess will be required to pay monthly, in addition to Rs. 2 for house-rent, a contribution of Re. 1 for mess-servants.

31. For students joining the native mess, the following table shows the annual cost of living at the College, the term being reckoned as nine months and a half and the vacation as two months and a half of the year:—

| | Tuition per mensem. | Board per mensem. | House-rent per mensem. | Total monthly charges. | Total per annum. | Grand total. |
|---|---|---|---|---|---|---|
| | Rs. | Rs. | Rs. | Rs. | Rs. A. | Rs. |
| Term .. ... ... ... | 8 | 7 | 2 | 17 | 161 8 | 189 |
| Vacation ... ... ... | 8 | 1 | 2 | 11 | 27 8 | |

32. All payments, whether on account of tuition-fees, messing or house-rent, must be made into the Principal's office on or before the 15th of the month for which the money is due, after which date no payment will be taken unless accompanied by a fine of Re. 1 for every three days of delay. If the payment is not made during the month for which it is due, the defaulting student's name will be struck off the College books, and he will not be re-admitted until he has paid all arrears with fines and the usual re-admission fee.

33. The monthly charge for messing may, if necessary, be altered from time to time in reference to the prices of provisions.

34. All breaches of discipline committed by any student of the College will be reported to the Principal, who will dispose of them according to the rules and practice of the Education Department.

35. A Conduct Register of each student in the College will be kept by the Principal. The Principal has no power to cancel or alter an entry once made and signed.

36. Students are liable to have their names placed in the Conduct Register as defaulters for the following offences:—

(i) Disobedience of orders.
(ii) Absence without leave.
(iii) Idleness.
(iv) Insubordination or disrespect to the College or Workshop authorities.

37. Students may be removed from the College for habitual or gross misconduct, for continued idleness or neglect of work, or for frequent entry in the Conduct Register. Every such removal shall be reported to the Director of Public Instruction, and any fees paid by the student shall be forfeited.

38. Every student will be responsible for any machines, tools or other articles that may be placed in his charge. He must produce them when called upon to do so, and must at once report any damage done to them. In case of loss or damage arising from carelessness, he may be called upon to pay the cost.

39. A certain number of the students will be appointed monitors, whose duty it will be to assist the College authorities in the maintenance of discipline. For the performance of this duty each monitor will receive a small sum monthly. Any monitor may be removed by the Principal for misconduct, or for inefficiency in the discharge of his duties.

40. No resident student will ordinarily be allowed to keep a private servant. This permission may be given under exceptional circumstances, but any servant so employed will be under the orders of the Principal.

41. On Sundays all resident Christian students, Protestant or Roman Catholic, will be required to attend the services held in their respective chapels.

42. All students will be required, while in the workshop, to wear a uniform dress, which will be supplied to them at cost price.

*43. Leave will be granted by the Principal only. No leave will be granted except on a written application.

44. No resident student may leave the College premises without the written order of the Principal, whether on special leave or on a general holiday.

45. European students will be encouraged to join the Volunteer Corps. Those who join it will be allowed such occasional leave as may be required by the regulations relating to volunteers.

46. One and two appointments in alternate years are now guaranteed to students of the College. The selected men are posted as Apprentice or Assistant Engineers in the Public Works Department.

47. All students are obliged to join the College Athletic Club, the subscription to which is Re. 1-8 per annum and the entrance fee Re. 1.

# ENGINEER DEPARTMENT.

*List of Books and Instruments to be procured by Engineer-students.*

Students will provide themselves with the following books and instruments:—

**First year**

- Hall and Steven's Euclid.
- Hall and Knight's Higher Algebra.
- Todhunter's Trigonometry.
- Kolbe's Inorganic Chemistry.
- Davidson's Linear Drawing.
- Davidson's Projection.
- Roorkee Treatise on Surveying.
- A good box of drawing instruments and set squares.

**Second year**

- Todhunter's Mechanics for Beginners.
- Wilson's Geometrical Conic Sections.
- Deschanel's Heat.
- Sylvanus Thompson's Elementary Lessons on Electricity and Magnetism.
- Brooker and Slingo's Electrical Engineering.
- Roorkee papers on Estimating.
- Building Construction, South Kensington Series, vols. I and III.

**Third year**

- Smith's Conic Sections.
- Preece and Sievewright's Text-book on Telegraphy.
- Heath's Geometrical Optics.
- Bloxam's Metals.
- Building Construction, South Kensington Series, vols. II and IV.
- Goodeve's Mechanism.

**Fourth year**

- Todhunter's Differential Calculus.
- " Integral "
- Besant's Hydrostatics.
- Austen's Introduction to the Study of Metallurgy.
- Bauerman's Descriptive Mineralogy.
- Geikie's Text-book of Geology.
- Holmes' Steam Engine.
- Wray's Instruction in Construction.
- Love's Hydraulics.
- Barry's Railway Appliances.
- Roorkee papers on Bridges, Roads, and Irrigation Works.
- Box of blowpipe utensils.

# ENGINEER DEPARTMENT.

## SYLLABUS OF INSTRUCTION.

### 1.—MATERIALS OF CONSTRUCTION.

CLASSIFICATION ... { (*a*) Stone, brick, tiles, terra-cotta, timber, metals. (*b*) Limes, cements, mortars, concretes, plasters. (*c*) Mastics, glue, paints.

#### STONE.

*Characteristics of Building Stone.*—Durability dependent on atmospheric influence and physical structure. Facility of working; hardness; strength; weight; appearance; position in quarry; seasoning; natural bed; agents which destroy stone.

*Examination of stone.*—Fracture. Tests:—crushing; absorption; Brard's test; acid test; Smith's test. Practical way of ascertaining weathering qualities.

*Classification of stone. Scientific.*—Siliceous, argillaceous, and calcareous; *Practical.*—Granites and other igneous rocks; slates; sandstones; limestones.

*Granite.*—Common granite. Syenite and syenitic granite; quarrying and dressing: uses to which granite is applied.

*Igneous rocks other than granite.*—Porphyry, gneiss, mica schist, hornblende schist, trap, basalt.

*Slates.*—Cleavage, plerry, quarrying, hardness, toughness, grain, veins objectionable, pyrites. Tests.

*Sandstones.*—Composition, colour. Practical classification. Fracture a test of quality. Weight and absorption.

*Limestones.*—Composition, texture, marbles, compact limestones, granular limestones, shelly limestones, dolomite.

*Artificial stone.*—Ransome's, Sorel's, Victoria stone, Garlick stone.

*Preservation of stone.*—Bituminous matter, drying oil, silicate of potash, silicate of lime.

*Quarrying.*—Mode of conducting quarrying operations in India. Blasting.

#### BRICKS, TILES AND TERRA-COTTA.

*Brick-earths.*—Effect of the following ingredients in brick-earths :—Alumina, silica, lime, carbonaceous matter, alkalies, salt, oxide of iron, reh.

Practical classification—Strong clays; loams, marls, malm.

Composition of a good brick-earth. Colour of bricks.

*Brick-making—Preparation of brick-earth* :—Unsoiling, digging and weathering, grinding, washing, tempering.

*Moulding.*—Slop moulding, sand moulding, pallet moulding, frog, form of mould, and size of brick.

*Drying.*—In sheds, out of doors, hacking, scintling.

*Burning.*—In clamps, in kilns, amount of fuel required, comparative advantages of clamp and kiln burning, Hoffmann's kiln, Bull's kilns.

*Characteristics of good bricks.*—Freedom from flaws, shape, absorption, texture.

*Tests for bricks.*—Fractured surface, Brard's test.

*Fire-clay.*—Uses, where found, composition.

*Tiles.*—Preparation of clay, moulding pot, and flat tiles, various forms of tiles in use in India.

*Terra-cotta.*—Nature of clay, preparation of clay, moulding, glazing, burning.

## Limes, Cements, Mortars, Concretes, Plasters.

*Constituents of limestone that do not produce hydraulicity.*—Carbonate of lime, sand.

*Constituents that produce hydraulicity.*—Clay, soluble silica, carbonate of magnesia, alkalies, sulphates.

*Classification of limes and cements.*—Fat limes, poor limes, hydraulic limes, cements.

*Varieties of lime in common use.*—Fat limes, grey chalk, lias, carboniferous, magnesian; limestones used in India; kunkur.

*Artificial hydraulic lime. Natural cements.*—Carbonate of magnesia, cement stones.

*Roman cement.*—Weight, strength, storing, uses. Medina and Atkinson's cements.

*Artificial cements. Portland cement.*—Manufacture from chalk and clay. Manufacture from limestones and shale. Tests of quality. Rough tests. Storing.

Strength when mixed with sand. *Scott's cement. Selenitic cement. Pasley's cement.*

*Lime and cement burning.*—Forms of kilns. Flare and tunnel kilns. *General rules for burning.*—Heat gradually applied, temperature, size of lumps, quantity of fuel, appearance of stone while burning. Overburnt and underburnt cements. Dead-burnt lime.

*Sand.*—Pit sand, river sand, sea sand, screening and washing sand. Examination of sand.

*Pozzuolanas.*—Natural and artificial pozzuolanas.

*Mortar.*—Ordinary mortar, cement mortar. Evils of fat limes. Hydraulic limes. Cements. Description of sand to be used in mortar.

*Water.*—Salt water, dirty water.

*Preparation, and mixing mortar.*

*Slaking lime.*—Quantity, time. Ground lime. Water.

*Mixing.*—Methods, quantities; bulk of mortar produced.

*Precautions in using mortar.*

*Concrete.*—The matrix. The aggregate; shape, size. Aggregates in common use:—Broken brick. Burnt clay. Gravel. Ballast Slag. Voids. *Proportion of ingredients. Mixing:*—Materials all mixed together: mixed separately. Relative advantages of the two methods.

*Laying concrete* :—In trenches. Under water. *Bulk of concrete produced. Expansion of concrete. Uses of concrete.* Coignet's Béton. *Strength of concrete. Monolithic structures in concrete.*

*On the action of foreign constituents in limestones and cements. Fat limes* :—Calcination. Slaking. Setting. Mortar. Action of sand. *Hydraulic limes and cements containing clay.*—Clay. Lime. Calcination. Proportion of clay. Effect in cements burnt at a moderate temperature. Effect in cements burnt at a high temperature. Composition of clay. Effects caused by different degress of calcination Hydraulic limestones. Cement stones containing a small proportion of clay. Cement stones containing a large proportion of clay. Slaking. Setting. Proportion of clay. Pozzuolana. Carbonate of magnesia. Sulphates.

*Plasters* :—Lime and cement plaster. Gypsum. Plaster of Paris. Stucco.

*Asphaltes* :—Characteristics of good asphalte. Methods of laying. Uses.

*White-wash.*

## Paints and Varnishes.

Paints. Distemper. Varnish. Mastics. Glazing. Papering.

## Timber.

*Growth of trees.*—Annual rings, medullary rays, sapwood, heartwood, felling, squaring.

*Characteristics of good Timber.*

*Defects in timber.*—Heartshakes, starshakes, cupshakes ; rind galls, upsets, foxiness, twisted fibres.

*Classification of timber.*—Pine wood or soft wood, leaf wood or hard wood.

*Seasoning timber.*—Natural seasoning, water seasoning, boiling and steaming, hot air seasoning, smoke-drying, scorching and charring.

*Causes of decay in timber.*—Continued dryness ; continued moisture ; alternate dryness and moisture ; continued moisture with heat. Dry rot. Positions in which dry rot occurs. Detection of dry rot, checking dry rot. Wet rot. Positions in which wet rot occurs.

*Destruction of timber by insects.*—Destruction by marine animals and whiteants, and modes of protecting timber from their attacks.

*Preservation of timber.*—By good ventilation and obviating moisture. By the use of oil paint. By the application of tar boiled with powdered chalk. Bethell's process of creosoting. Boucherie's process of injecting sulphate of copper. Margary's process. Payne's process.

*Measurement of timber.*

## Metals.

*Iron ores.*—Blackband. Red and brown hæmatite, magnetic, spathic, argillaceous.

*Preparation of ores.*—By washing. By roasting in clamps and in kilns.

*Smelting.*—Description of blast furnace. Hot blast. Cold blast Flux, slag. Comparative advantages of hot and cold blast iron.

*Pig iron.*—Foreign substances in pig iron. Carbon in a state of mechanical mixture and in chemical combination with cast iron. Effects of the following impurities upon cast iron, wrought iron and steel:—Silicon, phosphorus, manganese, sulphur.

*Cast iron.*—Remelting pig iron. Grey and white cast iron, mottled cast iron. To distinguish grey from white. Chilled iron. Malleable cast iron. Toughened cast iron. Descriptions of pig iron for casting in sand. Pattern. Cold shut, core, head, casting pipes, examination of castings, cast iron pipes, tests for cast iron.

*Production of Wrought Iron.*

*Effect on pig iron of*—Refining, puddling, shingling, rolling: contraction of wrought iron, defects in wrought iron, cold-short, hot-short, or red-short. Mitis castings.

*Tests for wrought iron.*—Tensile strength. Ductility. Methods of testing. Tensile tests, forge tests, testing rivets, appearance of fractured surface.

*Market forms of wrought iron.*

*Production of Steel.*—Amount of carbon in steel. Characteristics: —hardening, tempering. Varieties of steel; blister steel; spring steel; shear steel; cast steel; Bessemer process; Siemens-Martin process; Basic process.

*Hardening and tempering steel.*—Table of temperatures and colours. Degree of heat for hardening and methods of cooling. Hardening and tempering in oil.

*Case hardening.*

*To distinguish steel from wrought iron. Testing steel.*

*Forging iron.*—The form to be given to forgings, overheating.

*Forging steel.*—Shear, blister and cast steel.

*Welding.*—Wrought iron, steel.

*Preservation of iron.*—Corrosion, galvanising, painting, Dr. Angus Smith's process for cast iron pipes, Barff's process, Bright iron work.

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## 2.—CONSTRUCTION.

### Brick-laying.

General principles of brickwork. Bond.

Operations of brick-laying. Bond timber objectionable. Mortar joints. Fine joints. Lime putty.

Precautions against settlement. Joining new work to old. String courses and copes. Stone quoins.

Scaffolding.

### Masonry.

General principles of stone masonry. Ashlar. Block in course. Coursed rubble. Common rubble. Rubble backing. Strength of a mass of masonry as depending on the size of stones, the bond, and accuracy in dressing. Bonding—headers and stretchers; through bonds.

Quoins. Direction of beds in battering walls. String courses and copes. Pointing. Drystone masonry. Mechanism for moving large stones.

Instruments used in building. Scaffolding.

## Earthwork.

Preliminary arrangements to be undertaken by the Engineer. Preparation of plan and sections. Practical stability of earthwork. Of excavation in rock.

Setting out of earthwork. Base or formation level. Sides or slopes. Half breadths. Computation of volume of a piece of earthwork. Simpson's rule for volumes. Prismoidal formula. Use of tables in such computations. Setting out. Angles. Centre line. Side widths; on side-long ground. Use of the bevil plumb rule, clinometer, mason's level, and boning staves.

Execution of earthwork. The tools and implements used. Size and form of barrows. Distribution of labour. Dobbin carts. Earth wagons. Boring to ascertain nature of ground.

Cuttings. Equalisation of cuttings and embankments. Side cuttings. Spoil banks. Stripping the soil. The consecutive operations in forming a heavy cutting. The horse run with large barrows. Casting up by stages. Slips. Drainage.

Embanking and puddling. Preferable materials for embankments. Embankments formed in one layer. In two or more thick layers. Settlement of embankments. Side slopes, facing slopes. Embanking in side-long ground. Foundations of embankments. Punning. Trimming slopes.

## Carpentry.

*Joints and Fastenings.*

*Joints.*—Lapping, fishing, scarfing. Different forms of scarf. Halving. Dovetails. Notching. Cogging. Mortise and tenon joint. Chase mortises. Circular joints. Bridle joints. Post and beam joints. Strut and beam joints. Tie and brace joints. Suspending pieces. Wedging. Fox-wedging. Keys.

*Fastening. Pinning:*—Nails, spikes, trenails, screws. Bolts, washers, plates. *Straps:*—Heel straps, branched straps. Cast-iron shoes and sockets. Tie-beam plates. Shoe for foot of rafters. Double shoe Socket pieces. Protection of iron fastenings from decay.

*Built beams and ribs of timber. Trussed beams of timber.*

*Floors.*—Single floors, double floors, framed floors; wall plates, templates. Common joists, strutting joists, trimming joists. Floor boards. Ceiling joists. Precautions to be observed in laying floors, with respect to door and window openings and partition walls.

*Partitions.*—General remarks. Framed without doorway. With ordinary doorway in centre. With side door. Common partition. Brick-nogged partitions.

*Timber Roofs.*—Flat roof. Pitch of roof. Couple roof. Couple-close roof. Collar beam roof. King bolt roof without struts. King post roof. Queen post roof. Purlins. Rafters.

*Stairs.*—Dimensions of stairs. Rule for proportion of rise to tread. Method of laying out stairs. *Different forms of stairs :*—Straight, dogged-legged, geometrical. *Parts of wooden stairs :*—Strings, steps. General rules for planning stairs.

*Doors and windows.*—Ledged doors, ledged and braced doors, panelled doors, glazed doors. Door frames. Fixed sashes. Fanlights. Sashes hung on centres. General arrangements of sliding sashes.

## Foundations.

Importance of slight and uniform settlement. Various modes of attaining that object. Action of water on foundations. Various conditions dependent on nature of bearing strata.

Importance of ascertaining the character of bearing strata. Trial pits. Borings.

Dry foundations. Rock. Gravel. Sand. Mixed strata of rocks and clay. Shale. Clay. Expansion of clay when exposed. Bearing stratum underlying soft ground of considerable depth. Crust of good ground overlying soft substratum.

Mechanical construction of foundations. Footings. Planking. Use of sand, concrete and béton.

Land foundations on artificial bottom. Consolidation of soft ground by driving piles. Platforms of fascines, timber or concrete, forming floating foundations.

Foundations on good natural bottom under water. Piled foundations. Timber piling. Cast and wrought iron piling. Iron screw piles. Hollow cast iron cylinders. Brick wells, as employed in India. Sand pump. Solid foundations laid under water. Pierre perdue. Random blocks of béton. Béton laid in caissons lined with tarpaulin. Solid masonry built on the natural bottom by divers. Solid masonry in cribs.

Foundations on sites where the water can be temporarily excluded. Solid masonry sunk in caissons on a bottom dredged out and levelled with béton. The same on a piled bottom. Solid masonry built in a cofferdam.

## Arching.

Names of parts—Different forms of arches. Inverted arches.

*Brick arches.*—Rough brick arches, axed arches, gauged arches.

*Arches over openings in wall.*—Segmental face arch, semi-circular arch, straight arch.

*Stone arches.*—Ashlar. Rubble.

## Buildings.

Selection of site—Design of foundations and preparation of bed. Thickness of walls. Points to be attended to in building walls. Buttresses. Arches in walls. Floors of various kinds. *Roofs*—Different forms of trusses in wood and iron. *Roof covering.*—Various materials used for this purpose, and mode of applying. Ceilings, chimneys, fire-places. Doors and windows. Drainage and ventilation, lightning-conductors.

## Bridges.

*Temporary expedients for crossing rivers.*—Causeways, temporary bridges, ferry boats, boat and pontoon bridges, rope bridges.

*Masonry Bridges.*—Details of the various parts in brick and stone, with principles of design.

*Wooden Bridges.*—Various forms of trusses and details of parts.

*Iron and Steel Bridges.*—Different forms of girders used, with full details of joints, roadway, &c., and mode of calculating the strength of the various parts. Methods adopted for erecting bridges.

## Roads.

Fair-weather roads in districts liable to inundations. Permanent roads. Resistance of vehicles on roads variously paved. Ruling gradients. Staking out the centre line. Formation. Breadth and cross section. Earthwork. Side slopes. Culverts and drains. Road metalling. Paving with stone blocks. Maintenance and repairs. Hill roads. Street paving in towns.

## Railways.

Survey and choice of line. Gradients and curves. Resistance of railway trains on a level straight line. On curves and steep gradients.

Formation of roadway. Earthworks. Formation level. Base. Culverts. Regulations about bridges. Level crossings. Fencing. Mile posts. Gradient posts.

Permanent-way of railways. Gauge of railways. Ballast. Timber sleepers. Rails. Chairs. Rail joints, fish joints. Cast-iron sleepers. Wrought-iron sleepers. Cant of rails. Elevation of outer rail on curves. Sidings. Switches and crossings. Turntables.

Railway stations. Design and arrangement. Classification. Terminal stations. Intermediate stations. Selection of site. Details of terminal stations. Approaches, roads and yards. Position of principal buildings. Parallel or side-station system. Transverse or end-station system. Goods stations. Goods yard at small stations. Signals.

## Irrigation Works.

*Well-irrigation.*—Common machinery employed in India for raising water from wells.

*Canal irrigation. Inundation canals.*—General rules for the selection of best site for head works. Head sluices. Slope of bed.

*Permanent canals.*—Sources of supply, amount of water required, slope of bed, discharges of canals, section of channel, alignment of canal. Head works—weirs, regulators ; falls, rapids, locks, navigation channels, aqueducts, inlets, level crossings, super-passages.

*Distribution of water.*—Rajbahas. Modules.

*Tank-irrigation.*—Site of embankment. Different forms of embankment. Waste weirs. Irrigation sluices.

*River inundation and river improvement.*—General methods in use to improve the course of streams, and to render channels navigable.

## 3.—ESTIMATING.

General principles of estimating. Rules of mensuration of surfaces and solids.

The student will be exercised in taking out quantities and framing an estimate from working drawings of the following examples:—

A masonry culvert. A portion of road in cutting and embankment. A house. A wooden bridge. An iron bridge. A masonry bridge.

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## 4.—APPLIED MECHANICS.

### Definitions.

*Elasticity.*—Plasticity and rigidity. Stress, its nature and intensity. Tensile, compressive, and shearing stresses. Positive and negative senses of a stress. Stresses of uniform and variable intensities. Ultimate strength. Factor of safety.

### Tension.

*Simple tension.*—Work done in stretching a rod. Thin pipes under internal fluid pressure. Strength of prismatic solids under tensile stress when the resultant of applied forces does not coincide with the axis of the solid. Safe tensile co-efficients of various materials.

### Compression.

Classification of bars or pillars under compression:—Very short pillars, short pillars, long pillars, very long pillars. Methods of failure of these classes of pillars. Rondolet's, Hodgkinson's and Gordon's formulæ. Euler's formula. Fairbairn's formula for collapsing of tubes under fluid pressure. General remarks on the applicability of the above formulæ. Safe compressive co-efficients of materials usually subjected to a compressive stress: impact, pile driving.

### Transverse Strain.

Proof that the stress at each point varies as its distance from the neutral axis.

Determination of the position of the neutral axis.

Determination of the moment of resistance.

Calculation of moments of inertia of ordinary sections used in engineering construction.

Flanged girders:—Approximate and accurate methods.

Proportion of I beams for equal strength.

Beams of uniform strength.

*Bending moments and shearing forces.*—(Treated graphically and analytically).

Cantilever under single load at free end.

Cantilever under uniformly distributed load.

Cantilever under uniformly distributed load, and one or more detached loads.

Beams supported at the ends and loaded with detached loads at any point.

Beams supported at the ends and loaded uniformly.

Beams supported at the ends and loaded uniformly, and also with one or more detached loads.

Beams supported at the ends and loaded with a single detached moving load.

Beams supported at the ends, supporting an uniformly distributed moving load of length less than the span.

Beams supported at the ends, supporting an uniformly distributed moving load of length greater than the span.

*Beams supported at the ends and loaded at intermediate points.*—Conversion of detached loads into equivalent uniformly distributed load.

## Statics of Structures.

*Framework loaded at the joints.*

*Triangular frames.*—Diagram of forces for a single triangular frame. Triangular trusses. Cranes and derricks. Sheer-legs and tripods. Effect of the tension of the chain in cranes.

*Incomplete frames.*—Preliminary ideas. Simple trapezoidal or Queen post truss. General case of a funicular polygon under a vertical load. Suspension chains.

*Compound frames.*—Compound triangular frames for bridge trusses. Roof trusses in timber. Queen truss for large iron roofs. Diagram of forces in general.

*Framework girders.*—Warren girders under various loads. N trusses. Bowstring girders.

*Girders with redundant bars.*—Lattice girders, flanged beams.

## Deflection of Beams.

Deflection due to the maximum bending moment. General equation of deflection curve. Elementary cases of deflection and slope. Beams propped in the middle. Stiffness of beams. Stiffest beam that can be cut from a circular log.

## Shearing.

Distinction between tangential stress and normal stress. Equality of tangential stress on planes at right angles. Tangential stress equivalent to a pair of equal and opposite normal stresses. Web of a beam of I section. Method of computing the intensity of the shearing stress at any point in a bent solid.

## Resistance of Prismatic Solids to Simple Torsion.

Explanation of the phenomena of simple torsion.

A circular section, solid or hollow, most favourable form of prismatic solid for resistance to torsion.

Twisting moment. The limiting intensity of the resistance to torsion is that of the shearing stress.

Investigation of the resistance of a circular prism to torsion round its mean fibre.

The strength of axles subject to simple torsion. Values of the limiting intensity of working resistance to simple torsion for different materials.

Diameter of a shaft to transmit a given power.

### Blockwork Structures.

Stability at a plane joint. Stability of a series of blocks. Centres of pressure or resistance. Line, polygon and curve of pressures. Line of resistance, or polygon of centres of pressures. Moment of stability.

*Retaining walls.*—Theory of earth pressure. Angle of repose of different soils. Walls supporting a bank of earth with horizontal surface. Surcharged walls. Graphic methods of solution. Determination of the centre of pressure on any joint of a wall supporting a load of earth at its back Maximum intensity of stress at any joint in a retaining wall. Minimum intensity of pressure. Tensile stress at a joint. Effect of cohesion of mortar. Connection between maximum intensity of pressure on foundation course and power of resistance of earth foundation. Methods of equalising intensity of stress on foundation courses.

*Masonry arches.*—Definitions. Curve of pressures and line of resistance. Conditions of stability. Treatment of the weight of loads of different densities. Graphic process of determining the stability and resistance of any proposed arch by drawing the line of resistance. Depth of key-stone.

*Stability and resistance of abutments and piers.*—Graphic process of determining the position of resultant pressure on any joint of an abutment. Design of piers.

*Stability of foundations of structures in masonry and brickwork.*

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## 5.—HYDRAULICS.

### 1. General Principles.

Velocity and volume of flow. Principle of continuity. Flow in a stream. Steady and varying motion of streams. Fluid acting on piston. Theorem of Bernouilli. Hydraulic head.

### 2. The flow of Liquids through orifices.

Application of the theorem of Bernouilli. Velocity of flow due to given head. Co-efficient of velocity. Co-efficient of contraction. Co-efficient of discharge. Co-efficient of resistance. Connection between co-efficients of velocity and resistance. Discharge from large rectangular orifices. Borda's mouth-piece. Co-efficient of contraction for Borda's mouth-piece obtained theoretically. Incomplete contraction. Cylindrical and conical mouth-pieces. Flow over notches. Triangular

notches. Velocity of approach. Application of results to measurement of flow in streams. Francis' formula. Discharge of measured quantities of water for irrigation purposes. Italian and Spanish modules. Other forms of apparatus answering the same purpose. Discharge under varying head. Jet pump. Separating weirs.

### 3. The flow of Liquids in Pipes.

Laws of friction between liquids and surfaces. Froude's and Unwin's experiments. Loss of head due to friction in pipes. Hydraulic mean depth. Variation of co-efficient with velocity and diameter. Darcy's formula. Hydraulic gradient. Ordinary computations of size of pipes and volume of discharge. Loss of head due to bends, elbows, enlargements, &c.

### 4. Movements of Water in Canals and Rivers.

Mean velocity corresponding to given gradient. Variation of the co-efficient. Velocity at different parts of the section of the stream. Mean velocity in terms of surface and bottom velocity. Ratio of mean to maximum velocity. Forms of section of channel, circular, trapezoidal, egg-profile. Most economical section of channel with given side-slopes. Form of section for a constant velocity with varying discharge.

### 5 Impulse and Reaction of Water.

Pressure of a jet on a plane surface fixed or moving. Energy communicated to the moving surface and efficiency of jet. Velocity of surface for maximum efficiency. Resultant pressure on curved surface, direct impulse and reaction. Condition to avoid loss by shock when jet is received. Condition for least loss of kinetic energy when jet is discharged.

### 6. Hydraulic Machines.

Transmission of energy by hydraulic pressure. Power of hydraulic motors. Causes of loss of efficiency in water pressure engines, pumps, accumulators, and water-wheels.

Principle of momentum as applied to rotating machines; turning couple equal to the change of moment of momentum.

Speed for maximum efficiency and losses in reaction wheels.

Most efficient speed of turbines. Angles of moving and guiding vanes. Forms of vanes. Losses of efficiency. Regulation of power of turbines. Estimation and graphical representation of the diminution of total and pressure-head in flow through a turbine.

Centrifugal pumps with radial vanes. Speed for given lift with given efficiency. Utilisation of kinetic energy of whirl. Best form and dimensions of spiral chamber. Whirlpool chamber. Centrifugal pump with backward curved vanes. Losses. Volume discharged.

Efficiency of propellers. Jet propellers. Paddle wheel. Screw.

## 6.—MECHANICAL ENGINEERING.

### DESCRIPTION AND CONSTRUCTION OF THE ELEMENTARY PIECES OF MACHINES.

Shafting. Couplings. Clutches. Friction clutches. Plummer blocks or pedestals. Fixings, wall boxes, brackets, hangers. Footsteps. Bolts and nuts.

Tooth gearing. Spur wheels. Racks. Bevil wheels. Worm gearing. Modes of fixing wheels upon shafts.

Driving belts. Drums and pulleys. Fixing drums and pulleys upon shafts. Rope transmission. Telodynamic transmission.

Cranks. Eccentrics. Cams. Connecting rods.

Valves. Pistons. Stuffing boxes.

### STEAM ENGINE.

*Fuel and combustion.*—Chemical composition and physical properties of the different kinds of fuel. Calorific value of some elements and their compounds. Determination of the calorific value of the different kinds of fuel. Process of combustion. Formation of smoke and flame. Losses by incomplete combustion. Air necessary for combustion. Temperature of combustion. Density of burnt gas. Maintenance of draught, by convection; by artificial means. Transmission of heat from furnace gases. Waste of heat. Methods of stoking. Mechanical stokers.

*The Boiler.*—Types of boilers. Proportions to provide sufficient grate and heating surfaces. Proportions and methods of construction to provide sufficient strength. Construction to facilitate cleaning and examination. Boiler fittings.

*The Steam Engine in general.*—Types of engines. Horse-power. Relations between dimensions of cylinder, speed of piston or revolution, and power of engine. The design of the principal details of an engine. Piston, piston rod, connecting rod, crank shaft. The slide valve and eccentric. Link motions. Expansion valves. Zeuner's valve diagrams. The Indicator and Indicator diagrams. The condenser and air pump.

*The Locomotive Engine.*—Train resistance. Tractive power. Adhesion. Express and coupled engines. General description of ordinary engines. Goods engines. Limit of load on wheels. Fatigue of rails. Description of engines for exceptional circumstances. Engines for steep inclines. Engines for exceptionally heavy trains on moderate inclines. Engines for narrow gauge lines. Double traction. Fairlie engines.

General arrangements of engine and boiler. Reversing. Expansive working. Webb's compound engine. Brakes. Framing. Axle boxes. Springs. Axles. Wheels. Effect of curves on wear of tires. Provisions for reducing the effect of sharp curves. The tender. Ramsbottom's scoop.

### THERMODYNAMICS.

Measurement of temperature and quantities of heat. Relations between pressure, temperature, and volume of steam. Total heat of formation of steam.

External work done during evaporation. Relation between heat and work; Joule's equivalent. Internal work of evaporation.

Operation of a non-expansive working engine. Expenditure of heat and steam. Efficiency. Condensation water.

Calculation and graphical representation of the energy exerted by an expanding fluid. Relation between pressure and volume of expanding steam. Indicator diagram. Mean pressure.

Transmission of heat to and from metal of cylinder when steam is used expansively, and consequent limitation of economical ratio of expansion. Expenditure of heat and steam in expansive working engine. Efficiency. Advantage of steam jacket and superheating. Operation of compound engine. Indicator diagrams. Advantages of compound engine.

Efficiency of thermally perfect air engine. Reversibility. Carnot's principle. Maximum efficiency of any heat engine.

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## 7.—SURVEYING.

### Lecture Room Course.

(1) Construction of scales—Simple, diagonal, and vernier.

(2) Useful problems in surveying.—To avoid obstacles in the chain line—

- 1*st*—When the obstacles can be seen over and cahined round, but not across.
- 2*nd*—When it can neither be seen over nor chained across, but can be chained round.
- 3*rd*—When it can be seen over, but neither chained over nor round.

(3) To find the intersection of two lines meeting in a lake or river, and the distance to the point of meeting.

(4) To find your place in a survey by observation from that position to certain fixed points on the survey—

- 1*st*—With prismatic compass.
- 2*nd*—With pocket sextant.

(5) Investigation of various methods of tracing curves—

(*a*) Without angular instruments—

- By chords and offsets.
- By off sets from a common tangent.
- By successive bisection of arcs.

(*b*) With theodolite—

- By angles at the circumference when the point of intersection of the tangents to the curve is accessible.
- When the point of intersection is inaccessible.
- By two theodolites at starting points of curve.

(*c*) Serpentine curves.

(6) Plotting chain survey.
(7) Plotting survey with chain and prismatic compass.
(8) Plotting theodolite traverse by Gale's method.
(9) Plotting level sections.
(10) Computation for the reduction of the base line.
(11) Reduction to the centre of angles taken from satellite stations.
(12) Calculation of the sides of the triangles in a trigonometrical survey.
(13) Calculation of the relative vertical heights of the stations as determined by theodolite.
(14) Equalizing areas—
  (*a*) Of irregular polygons.
  (*b*) Of irregular offsets.
(15) Colouring of maps and surveys with the necessary printing of title and drawing of scales.
(16) Colouring of level-sections.
(17) Enlargement or reduction of plans by—
  (*a*) Pantograph.
  (*b*) Squares.
(18) Methods of entering the topographical details, horizontal and vertical styles.
(19) Conventional signs used in surveys and plans.

### Practical Astronomy.

(1) Astronomical definitions.
(2) Determination of the true meridian—
  By equal altitudes of a star.
  By maximum elongation of a circumpolar star.
(3) Determination of latitude—
  By meridian altitude of the sun with sextant and artificial horizon.
  By circummeridian altitudes of a star with theodolite.
  By observations on Polaris.
(4) Approximate methods of determining the meridian and latitude without the use of angular instruments.
(5) Construction of horizontal sun-dials and method of graduating dial-plate.
(6) Simple methods of determining the longitude in which the use of the nautical almanac is not required.

### Field Work.

*First-year Class.*

A small survey with chain only.
A more extensive survey (Botanic Gardens) with chain and prismatic compass.

A line of leve about two miles long, the same to be carefully checked.

Ground tracing

*Second-year Class.*

A line of levels about one mile long, the same being carefully checked.

A survey, about four square miles in area, by triangulation and traverse (Gale's), the details being filled in by plane-table.

Contouring. Laying out curves. Setting out half widths on side-long ground. Erection of profiles for embankments. Adjustments of instruments. Observations for determining the meridian and latitude.

*Third-year Class.*

Select a line of railway about five miles long; make a traverse along the same, filling in detailed plan by plane-table. Level over this line, and make the needful cross sections.

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## 8.—DRAWING.

Construction of scales. Geometrical construction. Curves of arches, &c. Descriptive Geometry. Orthographic Projection: Of Planes: Of Solids, under given conditions. Sections of solids. Intersection of solids. Development of solids. Shadows. Isometrical Projection. Perspective. Machinery. Topographical drawing.

### Work to be executed by students.

1. Printing. 2. Scales. 3. Geometrical Figures. 4. Arches. 5. Problems in Descriptive Geometry. 6. Projections and Intersections of solids. 7. Intersections of Roofs. 8. Elevations, sections and plans of buildings and bridges from copies. 9. Ditto from rough sketches and dimensions. 10. Projections of shadows (simple cases). 11. Free-hand sketches—(*a*) from copies, (*b*) from models. 12. A drawing from actual measurement. 13. Machinery. 14. A simple isometric drawing. 15. A simple perspective drawing. 16. Maps, Sections, &c.

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## 9.—PROJECT.

This will consist of the surveys and levels for a line of canal or railway, about 5 miles ong, with cross sections of streams crossed, accompanied by designs for such iron and masonry structures that may be required for the streams or roads that are crossed. The whole to be supplemented by a book of calculations showing how the necessary dimensions have been arrived at.

The drawings that will accompany this project are :—

(1) General plan of country showing adopted line.
(2) Longitudinal section of line.
(3) Design for a masonry bridge.
(4) Design for a plate girder bridge.
(5) Design for an open work bridge, such as a Warren, Lattice, or Bowstring girder.
(6) Such other designs as may be required to complete the project.

The designs will be got up in sufficient detail to enable the bridges, &c., to be ordered without further information.

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## 10.—MATHEMATICS.

### Algebra.

Addition, subtraction, multiplication and division of algebraical expressions (including fractions), highest common factor, lowest common multiple, involution, evolution, theory of indices, surds, simple and quadratic equations involving one or more unknown quantities. Theory of quadratic equations and quadratic expressions. Ratio, proportion, variation. Arithmetical, geometrical, and harmonical progressions. Mathematical induction, permutations and combinations. Binomial theorem, exponential theorem.

### Trigonometry.

Direction of measurement of straight lines or angles denoted by algebraical sign. Measurement of angles by degrees and circular measure. Definition of the trigonometrical ratios and inverse trigonometrical functions. Investigation of formulæ, including all angles which have the same sine, cosine or tangent. Formulæ expressing the sine, cosine or tangent of the sum or difference of two angles in terms of the trigonometrical ratios of the single angles, with formulæ derived from these. Limiting values of simple trigonometrical functions of an evanescent angle. Sum of a series of sines or cosines of angles in arithmetical progression. Solution of triangles. Properties of triangles. Determination of unknown heights and distances.

### Application of Logarithms.

Each candidate will be supplied with a book of mathematical tables, and required to extract all necessary information from the tables. Properties and use of logarithms. Numerical solution of triangles. Easy questions in algebra, trigonometry, mensuration, statics, dynamics, or hydrostatics, involving logarithmic calculation.

### Mensuration.

The areas of plane figures, and the application of Simpson's rules. Areas of surfaces. Volumes of solids, including the application of the prismoidal formula.

## Plane Geometry (including the Geometry of Conics).

Simple problems in the geometry of the straight line, triangle and circle, treated according to modern methods. The more important properties of the parabola ellipse and hyperbola section of a cone. Text-book, Wilson's Elementary Geometry and Conic Sections.

## Statics.

The composition and resolution forces, acting in one plane on a particle or rigid body. Moments. Bending moments. Conditions of equilibrium of a particle or rigid body, acted on by forces in one plane. Force diagram of a system of forces in equilibrium. Meaning of virtual work and work done by a force. Applications of the above to the solution of problem (the candidate to be allowed the option of adopting the graphic method of solution). Equilibrium of constrained bodies and the simple machines. Determination of centroids. Friction.

## Dynamics.

*Kinematics.*—Velocity and acceleration, uniform and variable. Angular velocity. Numerical value of velocity or acceleration dependent on units of time and space. Relative velocities and accelerations. Composition and resolution of velocities and accelerations. Formulæ connecting time and space described, velocity and acceleration.

*Kinetics.*—Newton's laws of motion. Units of mass, force and work. Relation between force, mass moved, and acceleration produced. Attwood's machine. Motion of projectiles in vacuo. Direct impact of bodies. Co-efficient of restitution. Constrained motion of bodies sliding down smooth curves. Formula (without proof) for the time of a small oscillation of a simple pendulum. Uniform motion in a circle. Conical pendulum. The principles of work and energy. Conservation of energy.

## Hydrostatics.

Definition of a fluid, a liquid, a gas. Density and specific gravity of a substance and of a mixture of liquids or gases. Pressure at a point. Equality of pressure in all directions in a fluid. Transmission of fluid pressure. The hydrostatic press. Determination of pressure at any point in a homogeneous liquid. Whole pressure on a surface immersed in liquid. Resultant, horizontal and vertical pressure on an immersed surface. Centres of pressure of parallelograms, triangles, circles, or ellipses immersed in any manner in liquid. Conditions of equilibrium of floating bodies. Boyle's and Gay Lussac's laws for gases. The barometer, thermometer, siphon, common pump, air pump, and diving-bell. The atmosphere, pressure at any height in it. Determination of heights by the barometer. Hydrostatic balance. Hydrometers.

## Differential Calculus.

Definition of a differential co-efficient. Differential co-efficient of a sum, product, and quotient. Differential co-efficients of simple

functions. Successive differentiation. Leibnitz's theorem. Taylor's theorem. Maclaurin's theorem. Expansions of functions. Maxima and minima values of functions of one variable. Differential equation of the tangent and normal to a curve.

### Integral Calculus.

Integration, a limiting form of summation. Integration of simple functions by parts and by substitution. Integration of rational fractions. Integration between definite limits of forms which are generally integrable.

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## CHEMISTRY.

*I.—Pure Chemistry.*—Physical properties of the metals used in the arts. Alloys. Behaviour of metals on being heated in contact with air. Investigation into the causes of alteration. Oxygen. Nitrogen. Composition of air. Hydrogen. Detonating mixture. Physical properties of non-metals. Allotropic modifications. Rapid, slow, and incomplete combustion. Oxides of carbon, sulphur, phosphorus, arsenic, silicon, boron. Metallic oxides. Combination of metals with sulphur. Sulphides of hydrogen and carbon. Preparation and properties of the halogens. Their compounds with hydrogen. Halogen salts. Conversion of oxides, sulphides, and chlorides into each other; roasting. Electrolysis of binary compounds. Displacement of one metal by another in binary compounds. Quantitive analysis of cuprous and cupric oxides. Synthesis and analysis of water. Analysis of the oxides of lead. Laws of definite proportions, of multiple proportions, and of relative atomic masses. Laws of combination by volume. Avogadro's law. Chemical notation. Quantivalence. Anhydrides; hydroxides; acids and bases. The more important oxy-acids. Formation of salts by the interaction of acids and bases. Salts, normal, acids, basic; anhydro-salts. Water of crystallisation and constitution. Formation of salts by the action of acids on oxides and metals. Double decomposition. Principles of alkalimetry and acidimetry. Reduction of oxy salts in solution by metals and by the electric current. Ozone. Hydrogendioxide. Oxides of nitrogen and chlorine; corresponding acids. Oxidising action of nitric, chromic, and permanganic acids; of chlorine, bromine, and hypochlorites. Hydrides of carbon (methane and ethylene), nitrogen, phosphorus, arsenic, antimony. Cyanogen; hydrocyanic acid. General methods of preparing oxides, hydroxides, chlorides, bromides, iodides, sulphates, nitrates, phosphates, carbonates. Solubility of salts; nature of solutions; mutual action of salts in solution; natural waters. The most important sources of the metals used in the arts. Determination of molecular formulas and atomic weights; vapour density; isomorphism; specific heat; depression of freezing point and vapour pressure. The periodic law.

*II.—Chemical Energetics: A—Thermo-chemistry.*—Object. Methods of investigation. Calorimeters for solutions and combustion. Thermochemical notation (Ostwald's). Thermal units. The fundamental laws of thermodynamics. Cycles. Relation between chemical

reactions and entropy. Allotropy. Hess' principle. Heat of combustion and formation; calculation of heat of formation. Neutralisation; behaviour of the more important mono-, di-, and tri-basic acids. Dissociation; typical examples; connection with temperature and pressure. Thermal changes attending solution and hydration. Exothermal and endothermal reactions. Application of the principles of Thermochemistry to the solution of technical problems.

*B.—Photo-chemistry.*—Actinometers; Bunsen and Roscoe's experiments. The laws of photo-chemical action. Photo-chemical induction. Contact effects. Assimilation of carbon by plants; storage of solar energy. Action of light on salts of silver, iron, chromium, uranium. Theory of photo-chemical action.

*C.— Eletro-chemistry.*—Faraday's laws. Electro-chemical equivalents. Calculation of E.M.F. of galvanic elements. Differences of potential due to contact of metals and electrolytes. Electrolytic conduction; polarization.

*III.—Chemical Technology.*—Chlorine. Bromine. Iodine. Hydrochloric, sulphuric, nitric acids. Phosphorus. Coal gas. Caustic potash and caustic soda. Nitre. Pearl-ash. Potassium bichromate. Sodium. Common salt. Sodium carbonate: LeBlanc, ammonia process. Borax. Soluble glass. Quicklime. Portland cement. Bleaching powder. Plaster of Paris. Magnesium. Glass and porcelain. Alum. Blanc fixe; zinc white; white and red lead. Silver nitrate.

*IV.—Practical Exercises.*—Qualitative analysis of solutions containing K, Na, Mg, Ca, Sr, Ba, Zn, Ni, Co, Fe, Al, Cr, Cd, Cu, Hg, Pb, Bi, Sn, Sb, As, Au, Ag. Analysis of chlorides, sulphates, nitrates, nitrites, carbonates, phosphates and silicates. Quantitative analysis, brass, bronze, and bar silver. Determination of sulphur and phosphorus in iron ores. Determination of iron in iron ores and in samples of iron by volumetric analysis. Assaying of iron in the dry way. Determination of gold by Skey's process. Testing of drinking water for ammonia, lead and sodium chloride, colorimetric tests. Analysis of limestones.

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## PHYSICS.

### I. Heat.

Expansion; Ramsden, weight-thermometer; Pierre; Regnault's experiments on the absolute expansion of mercury and the expansion of gases. Charles' law. Principles of thermometry. Temperature as measured by the expansion of solids, liquids, and gases. Mercurial thermometer; air-thermometer. Thermometers for various purposes. Density of solids, liquids, and gases. Absolute temperature. Calorimetry. Specific heats of solids and liquids; method of mixture, Regnault; Bunsen's ice-calorimeter. Specific heat of gases—at constant pressure, Regnault; at constant volume, Rontgen. Dulon and Petit's law; Neumann's law modified by Regnault. Changes of state of aggregation. Regelation. Critical temperature; Andrew's experiments. Measurement of heat of fusion and vaporization. Influence of pressure

on melting and boiling-point. Methods of liquefying gases. Maximum pressure of vapours; Dalton, Regnault; pressure of saturated steam below and above 100° C. Vapour densities; Hoffman's, V. Meyer's methods. Hygrometry; Regnault's hygrometer; psychrometer. Conduction; variable and permanent stages. Simple cases of steady flow across a plate and along a bar; Wiedemann and Franz' experiments. Convection. Joule's determination of the mechanical equivalent of heat.

## II. Statical Electricity.

Electrification by friction. Betz' and Ayrton's electroscope. Ice-pail experiment. Induction. Ramsden's machine. Electrophorus. Voss' and Wimshurst's influence machines. Electric work and energy. Indicator diagram of electric work. Exploration of electric field. Potential at any point of the field. Lines and tubes of force. Equipotential surfaces; lines of induction. Method of drawing lines of force and equipotential surface. Measurement of electricity; torsion balance; attracted disc electrometer; quadrant electrometer. Dimensions. Electrostatic units. Capacity. Condensers; electrification of two concentric spheres; Leyden jar, Lodge's hydraulic model. Specific inductive capacity. Absolute measurement of capacity; statical comparison of capacities; measurement of specific inductive capacity; standard air condenser.

## III. Current Electricity.

Chemical and thermal methods of producing currents; Daniell, Grove, Bunsen, Leclanche, Meidinger, Smee; thermopile; thermo-electric battery. Pyro-electricity. Classification of bodies as regards transference of electricity. Electrolytic conduction. Electrolysis of fused compounds and of saline solutions. Faraday's laws. The voltameter. Metallic conduction. Ohm's law. Kirchhoff's laws. Units of resistance. Poggendorff's rheochord. Resistance coils. Wheatstone's bridge. Resistance of battery. Resistance of galvanometer; Thomson. Electromotive force. Standard cells—Raoult, Lodge, Latimer Clark. Determination of electromotive force; statical method; Feehner's and Ohm's methods; Poggendorff's compensation method. Relation of electricity to heat; Joule's law; Lenz' experiments. Gaseous conduction. Disruptive discharge. Currents regarded as moving charges; Rowland's experiments. Flow of electricity and flow of electric energy; outlines of Poynting's theory. Phenomena attendant on the starting, stopping, and varying of a current. Oscillating discharges.

## IV. Magnetism.

Fundamental experiments. Magnetic field. The earth a magnet; magnetic elements; declination theodolite; dip-circle; bifilar magnetometer. Methods of magnetization. Relation of magnetism to electricity. Oersted's experiment. Tangent and sine-galvanometer; Thomson's reflecting galvanometer; Wiedemann's two-coil galvanometer. Electrodynamic experiments; the solenoid. Solenoidal magnet

and magnetic shells. Electromagnets; types. Permeability and methods of measuring it; its relation to temperature and mechanical stress; critical temperature, its relation to other physical properties. Magnetic hysteresis. Magnetic flux, magneto-motive force, reluctance. The law of traction. Induction of currents; Lenz' law. Direction of induced currents specified by reference to lines of magnetic force. Movement of lines of force with change of magnetization. Self-induction. Ruhmkorff's coil. Electromagnetic units. Theories of magnetism.

## V. Radiant Energy.

Laws of a vibrating particle. Harmonic vibrations. Transverse and longitudinal waves. Interference of waves travelling in the same and in opposite directions. Stationary waves. Composition of undulations; elliptical, circular, and rectilinear vibrations. Huyghen's principle. Reflection and refraction of thermal, luminous, and electric waves. Velocity of propagation; Foucault's and Fizeau's experiments. Plane, spherical, and parabolic mirrors. Single and double refraction. Prisms and lenses. Minimum deviation. Determination of refractive indices of solids and liquids. Melloni's experiments on radiant heat. Hertz' experiments on electric radiations. Outlines of Maxwell's theory of light. Dispersion. Spectroscope and spectra. Conditions of achromatism. Absorption of ætherial waves: diathermancy and athermancy; coloured bodies.

## VI.—Applied Physics.

1. *Heat.*—Pyrometers: Wilson, Siemens, LeChatelier. The double acting steam engine. Ice-making machines. Otto's gas-engine. Petroleum engines.

2. *Light.*—The sextant. Photometry; Ayrton's dispersion photometer. Telescopes. Microscopes. The camera obscura; principles of photography.

3. *Electricity and magnetism.*—Electro-metallurgy, Telegraphy and Telephony. Batteries in common use. Signals. Single needle instrument; sounder; Siemens' ink-writer; Siemens' A. B. C; relative merits. Siemens' relay. Line current, local current, double current working, translation. Duplex telegraphy; differential and bridge principle. Overground lines; supports, their preservation; insulators. Faults: in instruments; on line; total, partial, intermittent. Testing; Wheatstone's bridge; localising faults; loop test. Lightning conductors Terminals, single and multiple points; earth connection, its importance; the conductor proper: material, form; joints; clips and brackets; ridge circuits; incidental connections, gas and water-pipes; space protected; protection of dwelling-houses, magazines, chimneys; periodical inspection and testing; older and modern theories. The telephone and microphone. Electric bells and indicators. Dynamo-electric machinery. S. Thompson's definition of dynamo. The ideal simple dynamo and motor; connection between counter-electromotive force and maximum work. Efficiency. Causes of loss of energy. Types of armatures; armature coils and cores. Field magnets. Pole-pieces. Field magnet coils. Commutators, Collectors,

brushes, brush-holders. Curves of potentials and induction. Reaction of armature and field. Lead of brushes; angle of lead. Methods of exciting field magnets. Classification of dynamos. Examples. Dynamos of class I; closed coil armatures: gramme for large currents, Victoria dynamo; open-coil armature: brush. Dynamos of class II: alternate current dynamo. Dynamos of class III. Characteristics.

Transmission of electric energy. Accumulators. Transformers. Air-lines; insulators, testing; modes of attaching the wire; material for wires; joints; Thompson's lightning protector. Underground conduits; the three-wire system, lead covered cables. Comparison with other methods of transmitting energy.

Motors. Reckenzaun, Immisch. Appliances: electric pumping plant electric tramways, telpher lines, electric mining machinery.

Electric lighting. The brush lamp. Incandescent lamps. Electric welding. Electric measurements and measuring apparatus. The volt and Ampère. Ayrton's sulphuric acid voltameter. Calibration of galvanometers. Methods of shielding galvanometers. Proportional galvanometers. Ampère-meters and volt-meters. Ampère-balances. The ballistic galvanometers. Permanent magnet meters: Ayrton's. Spring meters: Siemen's electro-dynamometer, Ayrton's magnifying spring ammeter. Gravity control-meters. Electro-magnetic control-meters. Relative merits; testing for accuracy; calibration by the calorimetric and the voltameter methods. Cardew's voltameter. The Ohm; resistance coils; the shunt-box. Commercial Ohmmeters. The Farad and micro-farad. The Watt.

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## METALLURGY.

*Physical properties of metals*; testing machines; influence of impurities on the properties of iron and copper.

*Alloys.—Effect of temperature changes* on metals and alloys, with special reference to steel; annealing, hardening, tempering.

*Fuel.*—Classification; manufacture of coke; Wilson's gas producer; water gas; absolute, specific, and pyrometric heating power; assay of coal; Wright's calorimeter.

*Materials.*—Ores; fluxes; slags; oxidising and reducing agents; calculation of furnace charges.

*Furnaces.*—Hearths for roasting and refining and liquation; shaft furnaces; iron blast furnace, Rachette, Pilz, cupola, reverberatory furnaces, puddling-furnace, furnaces used in the smelting for copper and tin, cupellation, closed-vessel furnaces, Deville's blast furnace, furnaces used in the reduction of blende and cinnabar and in the manufacture of cement steel, the converter. Means of supplying air chimneys, blowing engines, Cowper's and Whitwell's stoves.

*Metallurgical processes.*—Classification, outline of typical processes. Blast-furnace process; puddling; Dank's furnace; Seimens' open hearth; Siemens-Martin; Bessemer; basic process; Darby's recarburisation process; tungsten steel, mitis metal. The Idria process. Huhner's furnace. Tin smelting. Extraction of zinc by the Belgian and Silesian methods. Heroult's aluminium process. Welsh process of extracting

copper from copper pyrite. Lead smelting, Flintshire. Extraction of silver from lead, Parkes, Pattinson, cupellation, concentration of gold in batteries, modern pan amalgamation. Augustin's wet process as practised in America; Plattner's chlorine process. Methods of producing sound castings.

*General considerations.*—Capital and labour; causes of failure; prices of metals.

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## GEOLOGY.

Object of geology.—Its relation to other sciences. The doctrine of uniformity; its limits.

I. *Astronomical Geology.*—Information obtained from meteorites and by the spectroscope. The nebular theory. Origin of internal heat. Climate in its geological relations; glacial and mild periods; Croll's theory modified by Wallace.

II. *Geognosy.*—The globe and its envelopes. Shape and nature of globe; density; probable internal condition; evidences of pressure and internal heat; isogeothermal surfaces. The age of the earth's crust, Tait's and Wallace's views. Persistence of continental ridges and abysmal depressions. *Petrography.* Microscopic character of rocks. Microscopic elements; their importance for the study of the history of rocks. Microscopic character of quartz, orthoclase, plagioclase, augite, hornblende, calcite. Essential and accessory constituents. Classification of rocks. Microscopic characters and essential constituents of the following rocks: limestone, dolomite, quartzite, flint, jasper, hornstone; amphibolite; gneiss, micaceous and chloritic schists, phyllite; granite; quartzporphyry; syenite, trachyte, phonolite, obsidian, pumice; diorite; diabase, dolerite, plagioclase-basalt; sand and gravel, sandstones, conglomerates, breccias, shale, clay; laterites; tuffs; shell-marl, coral-limestone, chalk, crinoidal limestone; tripolite, flint; guano; peat, lignite, coal, anthracite, graphite, oil-shale, petroleum, asphalt; bog iron ore, clay-ironstone.

III. *Dynamical Geology.*—Volcanic phenomena; description of volcanoes—kind, shape, distribution, relation to lines of weak resistance and instability. Theories of vulcanicity. Hot springs. Earthquakes. Secular upheaval and depression. Geological functions of air. Geological functions of water and ice; chemical and mechanical action; denudation and deposition; river valleys; peculiarities of Indian rivers; glacial erosion; formation of lakes. Geological functions of plants and animals; coral islands; Darwin's and Murray's theories.

IV. *Petrogenetic Geology.*—Origin of granite, syenite, diabase, diorite, and basalt. Origin of sedimentary rocks; minerogen, phytogen, and zoogen sedimentary rocks; theories on the origin of coal-beds; origin of laterite. Origin of metamorphic rocks; theories of metamorphism; local and regional metamorphism; origin of rock-cleavage. Ore deposits; origin and classification.

V. *Architectonic Geology.*—Forms of bedding. Surface markings. Concretions. Relative persistence of strata. Overlap. Groups of

strata. Joints. Strike and dip; outcrop. Monocline, syncline, anticline. Faults, origin and kinds. Intrusive phase of eruptivity; bosses, sheets, veins and dykes, necks. Interbedded phase of eruptivity; lavas tuffs. Unconformability.

VI. *Palæontological Geology.*—Object. Conditions for the entombment of organic remains. Preservation of organic remains in mineral, masses; fossilization. Uses of fossils in geology.

VII. *Historical Geology.*—Leading principles in stratigraphy. Equivalent strata; absent strata and formations. *Indian Geology.* Peninsular Area. The metamorphic series. The transition series. Lower and Upper Vindhyans; petrology; Vindhyan basin. The Gondwána system; geological position and characters; probable fluviatile origin; relation of Gondwána basins to existing valleys; lower and upper groups; Tálchir—Karhárbari; Barákar, ironstone shales; Rániganj; Rajmahál; the most important coal-fields. The Deccan trap series; area and petrology. Laterite; distribution, age. Post tertiary and recent formations; older river gravels and clays; kankar. Indo-Gangetic plain; upland and alluvial soils; red soil, regur, peat. General outlines of the geology of the Himalayan area.

VIII. *Physiographical Geology.*—Terrestial features due to disturbance of crust; monoclinal, symmetrical, unsymmetrical, reversed flexures; alpine type of mountain structure. Features due to volcanic action; the Deccan trap area. Features due to erosion; Indian examples.

IX. *Field Geology.*—Geological surveying; instruments; tracing of boundaries and faults. Sections; how to find direction and amount of dip; Dalton's construction; clinometer. Levelling; surface profile, datum level, bench-marks, methods of geological levelling, Abney's level. Lithology; practical exercises in the identification of Indian rocks.

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## MINERALOGY.

Province of mineralogy. Its relation to other sciences.

### I. Properties of crystals independent of direction.

Density and specific gravity. Methods of determining specific gravities; hydrostatic balance; pycnometer; Jolly's balance; floatation methods.—Thoulet's, Klein's, Retger's solutions. Separation of rock-forming minerals by the floatation method.

### II. Physical Crystallography.

*Elasticity.* Relation of co-efficient of elasticity to direction. Surfaces of elasticity. Method of determining co-efficients of elasticity in crystals. Classification of crystals with reference to elasticity. Physical definition of "crystal."

*Cohesion.* Cleavage. Fracture. Hardness: Mohs' scale. Corrosion figures; Lavizzari's experiment.

*Optical properties of minerals.* Kind and degree of lustre. Double refraction and polarization. Nicoll's prism. Classification of crystals

according to their optical properties. Uniaxial and biaxial crystals. Examination of crystals in parallel and convergent polarized light; polarization microscope. Circular polarization. Absorption of light; ideochromatic and allochromatic minerals; pleochroism, Haidinger's dichroscope, microscope with one nicol; distinction between augite and hornblende.

*Thermal properties.* Good and bad conductors; conductivity of single and double refracting crystals; expansion.

*Electrical properties.* Good and bad conductors; pyro-, actino-, and piezo-electricity, Hankel's researches.

*Magnetic properties.* Para- and diamagnetic minerals. Separation of rock-constituents by the electro-magnet.

III. Geometrical Crystallography.

Relation of physical properties to geometrical form; arrangement of molecules. Crystalline form; faces. Planes of reference; axes, parameters; indices; symbols. Law of rationality of indices, its independence of temperature. Principles of Miller's, Weiss', Nauman's notation. Fundamental form; its selection. Zones; tautozonal faces; zonal axis; law of conservation of zones. Symmetry; planes and axes of symmetry; principal and common planes. Classification of crystals. Fundamental law of physical crystallography. The six crystallographic systems characterized with reference to planes of symmetry. Simple forms and combinations. The holohedral forms of the regular system as modifications of the hexakisoctahedron. Combinations of hexahedron, octahedron, and rhombic dodecahedron. The holodedral forms of the remaining five systems. Closed and open forms; prismatic, tabular and pyramidal habit. Nature of hemihedrism. Tetrahedral, pentagonal, and plagihedral hemihedrism in the regular system. Rhombic resp, sphenoidal, pyramidal, and trapezohedral hemihedrism in the hexagonal and tetragonal systems. Sphenoidal hemihedrism in the rhombic system. Hemihedrism impossible in the monosymmetric and asymmetric systems. The nature of Tetartohedrism. Trapezohedral tetartohedrism in the hexagonal system; quartz. Apparently holohedral forms differ from real ones—loss of symmetry by combination with particular hemihedral forms, corrosion figures, circular polarization. Hemimorphism—tourmaline, hemimorphite. Crystallographic mimicry-leucite, sal-ammonia. Groth's method of deducing hemihedral and tetartohedral from holohedral forms. Isomorphism and heteromorphism. Isomorphous groups of elements. Iso-heteromorphous series of the calcite-arragonite group, of the augite-hornblende group, and of the felspars. Morphotropism and Isogonism. Hemitrophy. Twinning plane, twinning-axis, composition plane. Twins with parallel and non-parallel axes. Contact-twins and penetration twins. Distinctive features of hemitropes. Polysynthetic crystals. Twin striation and combination striation. Crystalline aggregates, druses. Pseudomorphism. Pseudomorphs by incrustation, substitution, and alteration; paramorphs. Measurement of angles; contact and reflecting goniometers; relative merits.

IV. Chemical Mineralogy. Calculation of formula. Groth's classification of minerals. Group tests.

V. DESCRIPTIVE MINERALOGY. A somewhat detailed description of the following minerals—

*Elements:* diamond, graphite, sulphur, bismuth, copper, silver, gold, platinum. *Sulphides:* pyrite, marcasite, arsenopyrite; leucopyrite; pyrrhotite; galena, chalcosite, sphalerite, argentite, cinnabarite; antimonite; chalcopyrite, bornite.

*Sulphosalts:* pyrargyrite, proustite, tetrahedrite, stephanite. *Oxides:* cuprite; zinkite; corundum, hematite, menaccanite; spinel, franklinite, magnetite, chromite; quartz, cassiterite, pyrolusite; geothite; limonite. *Oxysalts:* (*a*) carbonates—calcite, dolomite, magnesite, siderite, smithsonite; aragonite, witherite, strontianite, cerussite; azurite; malachite; (*b*) sulphates—anhydrite, barite; gypsum; (*c*) phosphates—apatite; (*d*) silicates—tourmaline; epidote; olivine; calamine; garnet; leucite, nephesite; muscovite, brotite, lithionite; prochlorite, rhipidolite; talc, serpentine; apophyllite stilbite, heulandite; hypersthene pyroxene, amphibol; orthoclase, microcline, albite, indianite, oligoclase-labradorite; kaolinite. *Haloid salts:* sylvite, halite, cerargyrite, fluorite; cryolite.

VI. PRACTICAL EXERCISES. Determination of specific gravities. Use of the scale of hardness. Exercises at the polarization microscope. Measurement of angles by the aid of contact and reflecting goniometers. Blowpipe analysis. Identification of Indian minerals by the aid of Brush's 'Manual of Determinative Mineralogy.'

# APPENDIX A.

*Course of Study for the Engineer Department.*

| | First year, A & B. | Second year, A & B. | Third year, A & B. | Fourth year, A. | Fourth year, B. |
|---|---|---|---|---|---|
| Mathematics ... | Algebra, Euclid, Trigonometry and Mensuration. | Statics, Dynamics, Geometrical Conic Sections. | Analytical Geometry, Differential Calculus, Elements of Integral Calculus. | Integral Calculus, Hydrostatics. | Integral Calculus, Hydrostatics. |
| Natural Science | Chemistry (or Physics). | Physics (or Chemistry) | Mineralogy ... | Geology and Metallurgy, Practical Chemistry. | Practical Chemistry. |
| Engineering ... | Field work ... | Building materials brick and stone masonry, earthwork, carpentry, foundations, roads, estimating masonry structures, direct stresses in building materials, surveying. | Construction of walls, floors, and roofs, railroads, irrigation works, arching retaining walls, stresses in roof trusses, estimating iron structures, mechanism, surveying. | Iron bridge construction, transverse stress, deflection, stresses in girder bridges and suspension bridges, torsion, hydraulics, steam-engine, architecture, preparation of civil engineering project. | Transverse stress, deflection, stresses in girder bridges and suspension bridges, torsion, steam-engine, workshop appliances, machine designs, preparation of mechanical design. |
| Drawing ... | Printing, geometrical and orthographic projections, scales. | Isometrical, topographical, and free-hand drawing. | Perspective, topographical, free-hand, architectural, and machine-drawing. | Mechanical, topographical, and free-hand drawing. | Machine-drawing, free-hand drawing. |

# ENGINEER DEPARTMENT.

## WORKSHOP COURSE.

Workshop hours ... 1 P.M till 3-30 P.M. daily, except Saturdays.

### First year.

*Carpenters' shop.*—A complete course in the use of carpenters' and joiners' tools. The students are required to make ordinary joints, stools, boxes, doors, windows, tables, trusses, and the usual framings required in engineering works. Their proficiency in this branch of their practical training is tested at the end of their first year by a carefully supervised examination, and every student must gain half marks before he can be promoted to a higher class.

### Second year.

*Blacksmiths' and Boiler-makers' shop.*—The course in this shop comprises the using and handling of the different tools; laying and managing the fires; drawing down, bending, jumping, welding, splitting, punching, chamfering and tempering. The students are required to make small forgings of tools, bolts, nuts, hooks, shackles, parts of roof trusses, and machines. In the boiler-makers' shop they are familiarised with the use of riveting tools and the process of riveting, and learn to punch and shear correctly with the machines for that purpose. Their proficiency is tested at the end of the year by a carefully supervised examination, and every student must gain half marks before he can be promoted to a higher class.

### Third year.

*Vicemen and Fitters' shop.*—The course in this shop consists of chipping, filing, and fitting to enable the students to gain experience in the tools used by this class of workmen, after which they make up various tools required in the Fitters' shop, and assist in ordinary fitting work. Their practical skill in this shop is not tested by examination, but in lieu of this they are required to keep note-books in which they sketch to scale the various details of the common machines in the shops, and are expected to be familiar with the working of all machines in the shop.

# ENGINEER DEPARTMENT.

## ANNUAL EXAMINATION.

### MAY.

#### ARITHMETIC AND ALGEBRA.

*1st and 2nd years.*

1. Simplify $2\frac{3}{7}$ of $\dfrac{15\frac{1}{2} - 7\frac{2}{3}}{17\frac{1}{7} - 14\frac{5}{8}} \div \dfrac{47}{83} + \dfrac{5\frac{4}{5}}{7\frac{1}{5} - 6\frac{3}{5}}$.

2. Express as vulgar fractions in their lowest terms the difference of $\cdot\dot{2}2\dot{5}8714\dot{2}$ and $\cdot\dot{4}2857\dot{1}$, and the sum of $3\cdot3\dot{1}\dot{5}$, $5\cdot0\dot{1}\dot{8}$, $3\cdot2\dot{2}\dot{1}$, $4\cdot2\dot{7}\dot{8}$.

3. A lawn-tennis ground is half as long again as it is wide; the cost of levelling it at 9*d.* per square yard is £176-8-0 : find the cost of enclosing it with an iron railing at 7*s.* 6*d.* per yard.

4. Find the present worth of £14-16-11, due at the end of 146 days, reckoning simple interest at the rate of $4\frac{1}{2}$ per cent. per annum.

5. A person holds New Zealand 5 per cent. bonds to the amount of £2,600; he sells out when they are at £104 per £100 bond, and invests the proceeds in shares in a mine paying 6 per cent.; what must be the price of the latter if his income from them exceed his former income by £8-13-4 ?

6. Express in factors $1 + (b - a^2)\,x^2 - abx^3$; $x^8 + x^4 + 1$; $(x + 1)(x + 2)(x + 3)(x + 4) - 24$.

7. Simplify $(yz + zx + xy)\left(\frac{1}{x} + \frac{1}{y} + \frac{1}{z}\right) - xyz\left(\frac{1}{x^2} + \frac{1}{y^2} + \frac{1}{z^2}\right)$.

8. Show that $\dfrac{x^2 - 3x + 4}{x^2 + 3x + 4}$ can never be greater than 7 nor less than $\frac{1}{7}$ for real values of $x$.

9. Solve—

(1) $(a - x)^3 + (x - b)^3 = (a - b)^3$.

(2) $\sqrt{7x - 5} + \sqrt{4x - 1} = \sqrt{7x - 4} + \sqrt{4x - 2}$.

(3) $x + y + z = 15$.
$x^3 + y^3 + z^3 = 495$.
$xyz = 105$.

10. Show that if $b^2 = a^2 + c^2$, then $a + b + c : c + a - b :: a + b - c : b + c - a$.

Sum the series (1) $2\frac{1}{4}$, $4\frac{1}{2}$, $6\frac{3}{4}$, to 23 terms.
(2) 12, 9, $6\frac{3}{4}$, to 20 terms.
(3) 4, 8, 16, to infinity.

11. How many triangles are there whose angular points are at the angular points of a given polygon of $n$ sides, but none of whose sides are sides of the polygon. (*Note.*—The sides of the polygon form the bases of the triangles.)

12. Expand $(a^2 - x^2)^{-\frac{1}{3}}$ to 6 terms; $(1 + x + x^2 + \ldots$ to infinity$)^2$.

If $a$, $b$, $c$, $d$ be any consecutive co-efficients of an expanded binomial, show that $(bc + ad)(b - c) = 2(ac^2 - b^2d)$.

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## GEOMETRY.

### *1st and 2nd years.*

1. Define plane surface, circle, rhombus, rectangle, chord, secant. When is the ratio of one magnitude to another said to be equal to that of a third to a fourth?

2. On the same base and on the same side of it there cannot be two triangles having their sides which are terminated at one extremity of the base equal, and likewise those which are terminated at the other extremity equal to one another.

3. To a given straight line apply a parallelogram which shall be equal to a given triangle, and have one of its angles equal to a given angle.

4. ABCD is a parallelogram and X, Y are the middle points of the opposite sides AD, BC; show that BX and DY trisect the diagonal AC.

5. If a straight line is divided equally and also unequally, the sum of the squares on the two unequal parts is twice the sum of the squares on half the line and on the line between the points of section.

6. Show that in any quadrilateral the squares on the diagonals are together equal to twice the sum of the squares on the straight lines joining the middle points of opposite sides.

7. Draw a tangent to a circle from a given point without the circumference. Give two methods.

8. If AB is a fixed chord of a circle, and P any point on one of the arcs cut off by it, then the bisector of the angle APB cuts the conjugate arc in a fixed point, whatever be the position of P.

9. On a given straight line describe a segment of a circle which shall contain an angle equal to a given angle.

10. Show that the bisectors of the angles of a triangle meet in one point.

11. If two triangles be equiangular to one another, the sides about the equal angles shall be proportionals, these sides which are opposite to equal angles being homologous.

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## Trigonometry and Mensuration.

*1st and 2nd years.*

1. Distinguish between circular and angular measure of angles. What are the advantages of the two systems? Find in circular measure the value of 33° 33′.

2. Make a table of the values of the sines, cosines, and tangents of the angles 30°, 45°, 60°, 120°, 135°, 210°.

3. A and B are angles each less than a right angle, but their sum is greater than a right angle. Prove that cos (A + B) = cos A cos B — sin A sin B.

4. Prove that—

(1) $\frac{1 - \cot\gamma \cot\delta}{\cot\gamma + \cot\delta} + \cot(\gamma + \delta) = 0.$

(2) $2 \sin(\alpha + \frac{\pi}{4}) \cos(\beta - \frac{\pi}{4}) = \cos(\alpha - \beta) + \sin(\alpha + \beta),$

and solve $4 \sin(x - a) \sin x = 2 \cos a - 1.$

5. Given the logarithm of a number to one base, show how to find the log. of the same number to another base.

$\log_e 5 = 1{\cdot}6094$, $\log_e 2 = {\cdot}6931$; find $\log_{10} {\cdot}8$.

6. Show how to solve a triangle when two sides and an angle opposite to one of them are given.

7. A and B are two points one mile apart. At A the angle CAB is 38° 19′, and at B the angle CBA is 132° 42′. The angular elevation of C above B is 10° 15′. Show that C is nearly 3,730 feet above B.

8. One regular hexagon is inscribed in, and another about, a circle of 10″ radius. Find the area of the external hexagon, and the fraction that the area included between the two hexagons is of the area of the circle.

9. A triangular grass field has its sides 50, 40, 30 yards. One road is cut from the middle of the longest side to the opposite angle, and another joining the middle points of the other two sides. Each road is 6′ wide. Express in fractions of an acre the area in grass.

10. Find the cost at Rs. 5 per 1,000 cubic feet of excavating the following trench:—Length 200′. Width of bottom 15′. Longitudinal slope of bottom 1 in 100. Depth at upper ends 10′. Slope of sides 1 in 10.

## Statics and Dynamics.

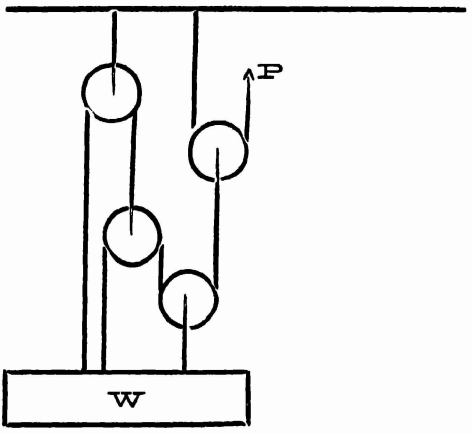
*2nd year.*

1. State and prove the polygon of forces. Is the converse of this proposition true? Give reasons for your answer.

2. If a system of forces in one plane acting on a rigid body is in equilibrium, the algebraic sum of the forces resolved in any direction is zero and the algebraic sum of their moments round any point in their plane is zero.

3. Find the C. of G. of a quadrilateral which has two side parallels. Give a graphical solution.

4. Find the mechanical advantage in the annexed system of pullies.




5. A cylinder, whose height is four times the radius of its base, is placed with its base on a rough inclined plane; co-efficient of friction = $\frac{1}{3}$. The angle of the plane is increased until the cylinder moves. Will it fall over or slide first?

6. A particle is projected in any direction not vertical and is then subject to the action of gravity only. Show that it will move in a parabolic path. Prove the geometrical property of the parabola on which your result depends.

7. Two bodies of 14 and 12oz. are fastened to the ends of a string which passes over a fixed smooth pulley. Neglecting the weight of the string and the inertia of the pulley, find (1) how far they move in 3 seconds from rest, (2) the distance described in the 2nd second, and (3) the velocity after $2\frac{1}{2}$ seconds.

8. By the direct collision of imperfectly elastic bodies the *vis viva* of the system is diminished.

A body impinges directly on another at rest. If the co-efficient of restitution is equal to the ratio of the two masses, find their motion after impact.

9. Define Kinetic and Potential Energy. Give examples.

A train of 60 tons moving at 15 miles an hour on a level line runs, when the steam is cut off, a quarter of a mile before stopping. Find the mean resistance in lbs. weight and the time taken to stop.

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## Engineering.

*2nd year.*

1. Where are the following found in Bengal?—Sandstone, laterite, fire-clay, felspar.

2. Describe Bull's patent trench kiln, and give a short account of its working. Give the dimensions of an ordinary brick as made at Akra.

3. What is Portland cement? How is it made, and how would you test it?

4. Write out a specification for concrete to be used in the foundations of an ordinary building. What depth of concrete would you provide for a single-storied house to be erected at Sibpur?

5. Describe the processes through which kankar passes, when it is being prepared for use as mortar.

6. State the uses the following trees are put to, and give their botanical names:—Babul, semul, sissu, sal, teak, padok.

7. Describe the process of creosoting timber. Distinguish between wet and dry rot in timber.

8. Describe the appearance and give the composition of white and grey pig-iron. Which is the better adapted for conversion into wrought-iron, and why?

9. What point should be attended to in examining iron castings with a view to ascertaining their quality and soundness?

10. Describe the manufacture of steel by the Bessemer process.

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## Surveying.

*1st and 2nd years.*

1. Describe fully how a prismatic compass survey is carried out, and show how you would keep a field book of a small circuit round a tank composed of four lines AB, BC, CD, DA, giving imaginary bearings, chainage and offsets.

2. The horizontal plate of a theodolite is divided into divisions, each of which represents $\frac{1}{4}$ of a degree; show how the vernier should be divided so that you may read to $\frac{1}{3}$ of a minute. Construct a scale of $1\frac{1}{2}$ feet to the inch and mark the length representing 3′ 7″.

A survey is plotted to a scale of 1 inch = 1 mile: what is its representative fraction? Construct a diagonal scale for this survey, showing furlongs and distances of 20 yards.

3. A line whose true length is 1,875 feet is chained by you, and you note its length as 1,900 feet; what is the true length of your measuring chain?

4. The following readings are taken with a level from a bench mark whose reduced level is 186·23—

1·32, 3·89, 5·67, 8·93, 6·54 at 1st setting up.
2·31, 7·49, 4·38, 3·42 at 2nd setting up.
1·28, 5·63, 11·07, 3·50 at 3rd setting up.

Show how these would be entered in a level book, and give the arithmetical checks.

5. How is a right angle set out with a chain? Hence, show how to avoid on the chain line an obstacle through which you cannot go or see, and pick up the correct chainage and direction of your original line again.

6. Describe accurately how a base line is measured for a trigonometrical survey.

7. Describe Gale's Traverse System. What checks have you on a closed survey?

8. Show how the pocket sextant is used for determining heights, such as that of a factory chimney.

9. How can you find the variation of a prismatic compass without any astronomical observations?

10. State in order the permanent adjustments of a dumpy level.

1st-year to do Nos. 1, 2, 3, 4, 5.

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## Drawing.

### *1st and 2nd years.*

1st-year students will answer questions 1, 2, 3, 4, 6, 7, and 8.
2nd-year „ „ „ „ 2, 4, 5, 6, 7, 8, and 9.
All working lines are to be left.

1. (*a*) Draw, without using a protractor, a regular pentagon of $1\frac{1}{2}$ inches side.
   (*b*) Draw an ellipse with major axis $3\frac{1}{2}$ inches and minor axis $2\frac{1}{2}$ inches.

Show how to draw a tangent and a normal to an ellipse at any point.

2. On a straight line, 3 inches long, construct geometrically a rectangle equal in area to a square of 2 inches side.

3. (*a*) What is meant by the "representative fraction" of a scale.

(*b*) Construct a simple scale of feet and inches. R.F.$=\frac{1}{36}$.

4. The distance between two places known to be 4·23 miles apart measures 12·69 inches on a map: construct the corresponding scale of miles, showing furlongs, and diagonally, spaces of 10 yards.

5. Construct a vernier scale to read to tenths and hundredths of an inch; and mark on it a length of 2·76 inches.

6. The accompanying drawings are plan and elevation of a masonry reservoir with steps all round it. Draw sectional elevation on the line AB.

7. Draw projections of a pyramid on a square base of 1 inch side, and height 2 inches, when resting on one of the edges of its base, which is inclined at an angle of 30° to the horizontal plane, and the horizontal projection of its axis makes an angle of 45° with the vertical plane.

8. AB, BC and DE, EF are the traces of two planes which intersect one another. Draw the projections of their intersection.

9. Draw in isometric the figure in section in question 6.

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## Chemistry.

### *1st and 2nd years.*

1. To perform a certain experiment I require at least 1,200 ccm. of sulphuretted hydrogen absolutely free from hydrogen. What materials would you use to prepare the gas; and knowing that the temperature at the time of filling the apparatus will not exceed 30°C., and that the pressure will not be less than 740 mm., what will be the minimum quantities of those materials which have to be used in the experiment?

2. Briefly describe the best methods of preparing the halogen compounds of hydrogen. In what points do these compounds resemble each other?

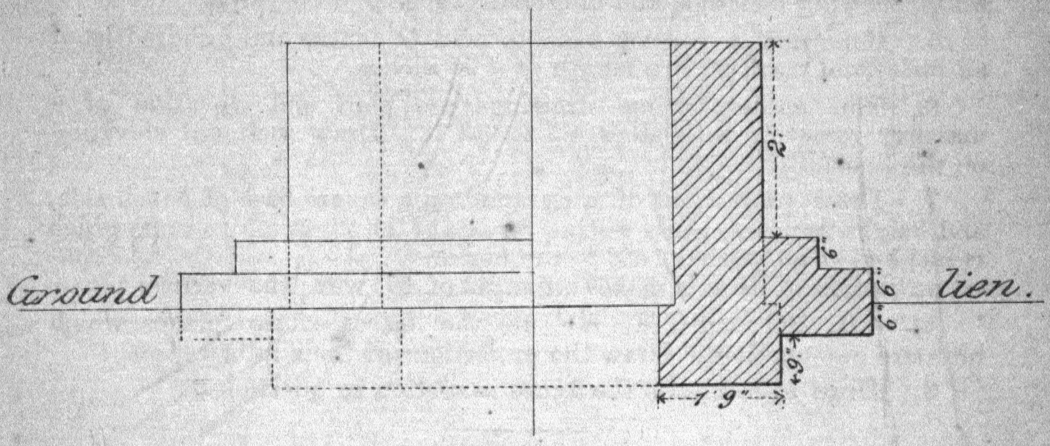
3. A mineral has the following percentage composition. What is its formula?

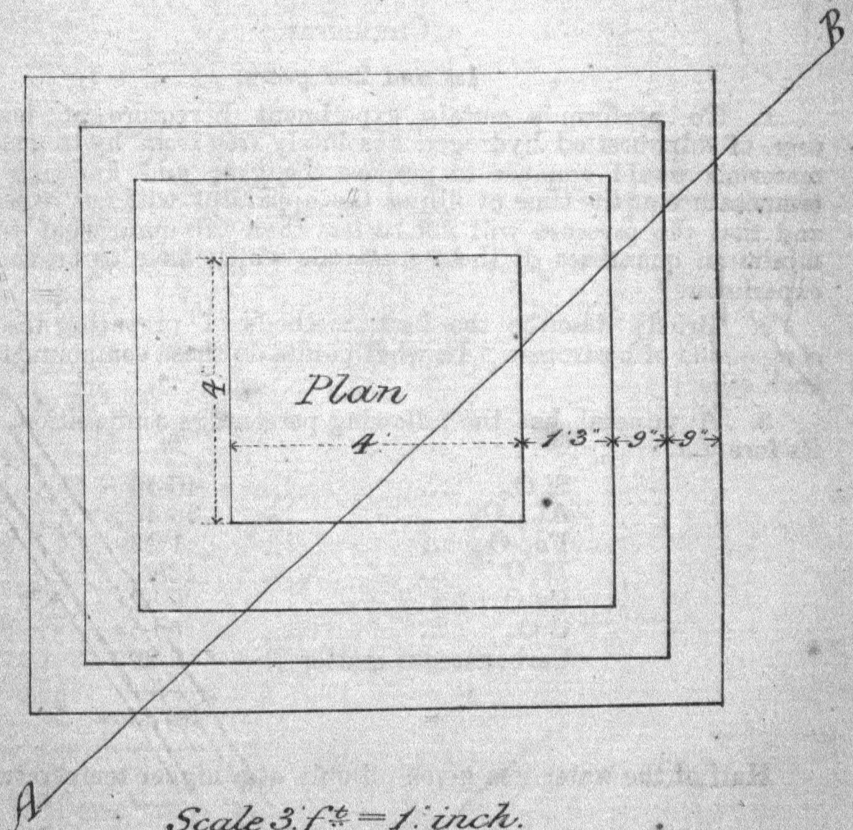
| | |
|---|---|
| $SiO_2$ ... ... | 46·46 |
| $Al._2O_3$ ... ... | 36·37 |
| $Fe_2O_3$ ... ... | 1·22 |
| $H_2O$ ... ... | 13·61 |
| CaO ... ... | 0·82 |
| $CO_2$ ... ... | 0·65 |
| Carbonaceous matter ... | 0·20 |
| | 99·33 |

Half of the water was given off only at a higher temperature.

# QUESTION. 6.

*Half elevation and Section.*




Scale 3 f$^{t}$ = 1 inch.

4. The density with respect to air of nitric fumes was found to be 1·783 at 97·5°C. and under a pressure of 760 mm. of mercury. Supposing the red fumes, which contained only nitrogen peroxide, to have been a mixture of $NO_2$ and $N_2O_4$, what was the composition by weight of the gaseous mixture?

5. How would you prepare chemically pure hydrogen for laboratory purposes?

6. What is meant by the terms empirical, rational, and graphical formulæ? Give examples.

Fully explain why the formulæ of nitric and sulphuric acids are frequently written.

$$NO_2.OH, \text{ and } SO_2\begin{cases}OH\\OH\end{cases}$$

7. Write down the general formulæ of the acid and normal ortho, pyro, and metaphosphates of monovalent, bivalent, and trivalent electropositive radicals.

What is the formula of normal potassium hypophosphite?

8. Give examples of the direct conversion of oxides, sulphides, and chlorides into each other.

9. How would you prove that the atmosphere contains oxygen, nitrogen, and carbon dioxide?

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## Physics.

*2nd year.*

1. How did Regnault determine the absolute density of air? The following are data obtained by him:—

$p = 12{\cdot}778266$ gr. at 0° and 760 mm.
$p^1 = 1258{\cdot}55$ gr. at 4·2° and 757·89 mm.
$P = 11126{\cdot}17$ gr. at 6·2° and 761·77 mm.

(The meaning of the symbols p, $p^1$, P will be clear to any one who can describe Regnault's method correctly.)

2. Show how the heat of fusion and the specific heat of a substance in the liquid state can be determined by making two similar experiments, the method used being the method of mixtures.

3. State Dalton's laws concerning the pressure of a mixture of a gas and a vapour, and describe an apparatus for studying the facts in connection with the formation of vapours.

4. How did Regnault determine the maximum pressure of steam for temperatures above 50°C.?

5. Find the weight of 20 litres of moist air, free from carbon dioxide and ammonia at a temperature of 35°C. and a reduced pressure of 756 mm., the hygrometric state being 70 per cent. (maximum pressure of aqueous vapour at 35°C. = 41·82 mm.)

6. Discuss the relative advantages and disadvantages of the various forms of hygrometers.

7. How did Fizeau determine the velocity of light in air?

8. Describe and explain the theory of Hadley's sextant.

9. Find the apparent distance between the point of a lead pencil in contact with the surface of a glass mirror and its image (index of refraction of glass = 1·53).

10. Find the positior of the image formed by a spherical lens of glass, the radius of curvature of which is equal to $r$, the distance of the object from the centre of the sphere being = $d$.

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## Estimating.

*2nd year.*

### Culvert.

Take out the quantities of—

(*a*) Concrete in foundation.

(*b*) Arch masonry.

Plain masonry in foundation and superstructure.

# ENGINEER DEPARTMENT.

## FIRST EXAMINATION IN ENGINEERING, 1892.

### Arithmetic and Algebra.

*Examiner*—Mr. J. H. Gilliland, B.A.

1. Simplify $\frac{2\frac{7}{8} + \frac{3}{5} \text{ of } 9\frac{3}{5} + 3\frac{11}{12}}{117\frac{1}{4}\frac{3}{6} - 106\frac{1}{15}} \times \frac{1\frac{2}{3} \text{ of } \frac{3}{5} \text{ of } 21}{23} \text{ of } \frac{3\frac{5}{6}}{5\frac{3}{12}}$.

2. Reduce $\left\{ \frac{2\cdot8 \text{ of } \dot{2}\cdot\dot{2}\dot{7}}{1\cdot\dot{3}\dot{6}} + \frac{4\cdot4 - 2\cdot\dot{8}\dot{3}}{1\cdot\dot{6} + 2\cdot\dot{6}2\dot{9}} \quad \frac{6\cdot8 \text{ of } 3}{2\cdot25} \right\}$ shillings to the decimal of £1.

3. A, B, C are partners. A receives two-fifths of the profits, B and C dividing the remainder equally. A's income is increased by Rs. 220 per mensem, when the rate of profit rises from 8 to 10 per cent. Find the capital of A, B and C.

4. A cubical block contains 4 cubic feet 1,088 cubic inches; find the number of square feet, etc., in its surface.

5. Solve the equations (i) $\frac{5x-14}{3\frac{1}{2}} - \frac{4-\frac{1}{7}(3x-3\frac{1}{2})}{6} = \frac{1}{2}$.

(ii) $\frac{2}{x+1} + \frac{3}{x+3} = \frac{5}{x+2}$.

(iii) $(x-1)(x+1)(x+2)(x+4) = 7$.

6. $\alpha$ and $\beta$ are the roots of $ax^2 - 2bx + c = 0$; show that

$$\frac{\alpha^3 + \beta^3}{\alpha^2 + \beta^2} = \frac{b(4b^2 - 3ac)}{a(2b^2 - ac)}.$$

7. Find the sum of $n$ terms of a series in Arithmetical Progression. Sum the series $\frac{1}{2}(a-x) + x + \frac{1}{2}(5x-a)$ + &c. to 19 terms. Sum to infinity the series $1\frac{1}{3} + 1\frac{1}{6} + 1\frac{1}{4\frac{1}{8}}$ + &c.

8. Find the number of permutations of $n$ things taken $r$ at a time.

From 5 corporals and 40 privates, in how many ways can a party of 5 be chosen, so as always to include one, and only one corporal?

9. Write down the $(r+1)^{th}$ term in the expansion of $(a+x)^n$. Show that the coefficient of the $(r+1)^{th}$ term in the expansion of $(1-4x)^{-\frac{1}{2}}$ is $\frac{\lfloor 2r}{\{\lfloor r\}^2}$.

If $x$ be a small quantity whose square may be neglected, find the value of $\frac{\sqrt{4-x}}{3-\frac{x}{2}}$

10. Show how to expand $e^x$ in a series of ascending powers of $x$.

Prove that $\frac{1}{2}+\frac{(\frac{1}{2})^3}{3}+\frac{(\frac{1}{2})^5}{5}+\ldots\ldots\ldots=\frac{1}{2}\log_e 3$

and that $\frac{1}{\lfloor 3}+\frac{2}{\lfloor 5}+\frac{3}{\lfloor 7}+\ldots\ldots\ldots=\frac{1}{2e}$.

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## Plane Geometry and Geometrical Conics.

*Examiner*—Mr. J. H. Gilliland, B.A.

1. The opposite sides and angles of a parallelogram are equal and the diagonal bisects it.

The longer side of a parallelogram is double of the shorter. Prove that the lines bisecting the four angles will enclose a parallelogram whose diagonal is equal to the shorter side of the original parallelogram.

2. Angles in the same segment of a circle are equal to one another.

Two chords AB, CD of constant lengths placed in a circle ABCD, subtend angles at the centre whose sum is equal to two right angles. AC and BD intersect inside the circle at P. Show that APD is a right angle.

3. Describe a triangle each of whose base angles shall be double of the vertical angle.

ABCDE is a regular pentagon: prove that

the sq. on BE = rect. AB. BE + the sq. on AB.

4. The sides about the equal angles of equiangular triangles are proportionals.

The exterior bisector of the angle A of a triangle ABC cuts the base BC produced in D, and the circumscribing circle in E. Prove that the rect. AB. AC = the rect. AE. AD.

5. The feet of the perpendiculars form the angular points of a triangle on the opposite sides, and the middle points of those sides all lie on a circle. State any other properties of this circle which you are acquainted with.

6. Tangents to a parabola at the extremities of a focal chord intersect at right angles on the directrix.

QSQ′ is a focal chord of a parabola and tangents at Q, Q′ intersect in Z. Show that $SZ^2 = SQ.SQ' = SA.PQ$.

7. Draw a pair of tangents to an ellipse from an external point, and prove that they subtend equal angles at the focus.

8. In the ellipse, prove that PF. PG = $BC^2$ and PF. CD = CA. CB.

Hence show that the sum of the squares on the normals at the extremities of conjugate diameters is constant.

9. The tangent at any point P of an hyperbola meets the asymptotes in L and l. Show that Ll is bisected at P, and that the rectangle CL. Cl is constant.

10. The tangents at the extremities of a focal chord of a conic meet the latus rectum in points equi distant from the focus.

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## Trigonometry and Mensuration.

*Examiner.*—Mr. J. H. Gilliland, B.A.

1. The sides of a triangle are 55, 48 and 71 feet respectively. Calculate its area in square feet to seven places of decimals.

2. The radius of a sphere is 5 feet. If a section be cut off by two parallel planes, so that the radii of the ends are 4 feet and 3 feet respectively, find the area of the curved surface thus cut off, (i) when the sections are on the same side of the centre, (ii) when on opposite sides of it.

3. Calculate the area of a circular segment whose chord is 105 feet long and whose arc subtends an angle of 103° 14′ at the centre.

4. Prove the formula

$$\cos(A-B) = \cos A \cos B + \sin A \sin B.$$

Express cot (A + B + C) in terms of cot A, cot B and cot C.

If $\tan^2\theta = 1 + 2\tan^2\phi$, then $\cos 2\phi = 1 + 2\cos 2\theta$.

5. Find tan 15°, cos 36° and sin 67½.

6. Eliminate, $\theta$ between the equations

$$\left.\begin{aligned} 4x &= 3a\cos\theta + a\cos 3\theta \\ 4y &= 3a\sin\theta - a\sin 3\theta \end{aligned}\right\}$$

7. Given $c = 426$ feet, $b = 354$ feet and A = 49° 16′, find the angles B and C.

8. Find an expression for the radius (R) of the circle circumscribing the triangle ABC, and also the radius ($r_a$) of the circle escribed to the side $a$.

Show that $\dfrac{2s}{r} + \dfrac{a}{\frac{r}{a}} + \dfrac{b}{\frac{r}{b}} + \dfrac{c}{\frac{r}{c}} = 8R\left(\dfrac{1}{a} + \dfrac{1}{b} + \dfrac{1}{c}\right)$.

9. Enunciate and prove De Moivre's Theorem.

Prove that $\cos\theta = 1 - \dfrac{\theta^2}{\underline{|2}} + \dfrac{\theta^4}{\underline{|4}} - \&c.$

10. Show how to expand $\cos^{2n}\theta$ in a series of cosines of multiples of $\theta$.

Expand $\cos^{8}\theta$ by this method.

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## Statics and Dynamics.

*Examiner.*—Mr. J. H. Gilliland, B.A.

($g$ is to be taken = 32.)

1. Enunciate and prove the "Triangle of Forces" and its converse.

Three forces P, Q, R act on a particle, the angles between Q and R, R and P and P and Q being $\alpha$, $\beta$, $\gamma$ respectively. Show that the resultant

$$= \left\{ P^2 + Q^2 + R^2 + 2QR\cos\alpha + 2RP\cos\beta + 2PQ\cos\gamma \right\}^{\frac{1}{2}}.$$

2. Show how to find the resultant of two "like" parallel forces.

Three parallel forces act at the angular points of a triangle ABC, and their resultant acts at the centre of the inscribed circle. Compare the forces.

3. Define the moment of a force and the bending-moment of a beam.

A uniform rod AB of weight W and length $a$ is supported in a horizontal position at A and B. At a point C, distant $\frac{a}{3}$ from A, a weight $w$ is placed. Find the bending-moment at any point of the beam: (i) between C and A, (ii) between A and B.

4. Find the centre of mass of a triangular pyramid and of a solid cone.

The radii of the faces of the frustrum of a cone are 4 inches and 8 inches respectively, and the distance between them is 7 inches. Find the position of its centre of mass.

5. State the laws of statical friction, and find the conditions of equilibrium of a body resting on a rough plane inclined at an angle $\alpha$ to the horizon, and acted on by a force which makes an angle $\theta$ with the plane.

Given the angle of friction = 15°, show that the *least* force which can support a mass of 2 tons on a rough plane whose inclination to the horizon is 45°, is equal to the weight of 1 ton. What is the least force which will pull the 2 tons up the plane?

6. Prove the formula $s = \frac{1}{2}ft^2$.

A stone is dropped down a well and the splash is heard 5·94 seconds later. What is the depth of the well? (take velocity of sound = 1,100 feet per second).

7. Enunciate the second Law of Motion. Employ it to determine the motion after impact of two imperfectly elastic balls of given mass which impinge directly with given velocities.

8. Show that the path of a projectile in vacuo is a parabola.

A given mass is projected in any direction with a given velocity. Show that the increase in its kinetic energy at any instant is the exact equivalent of the work done on it by gravity.

9. A railway train, moving at the rate of 45 miles per hour, comes to the foot of an incline of 1 in 170 when steam is shut off. Given the resistances of friction, etc. = 14lbs. per ton, find how far up the incline the train will go.

10. If the weight of the train in question 9 be 280 tons, find the horse-power required to maintain a speed of 45 miles per hour on level ground (resistances as before).

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## Analytical Geometry.

*Examiner.*—Mr. J. H. Gilliland, B.A.

1. Find an expression for the length of the perpendicular from the point $(x', y')$ on the line $Ax + By + C = 0$.

Find the equation of the locus of a point which moves so as to be always equidistant from the lines $Ax + By + C = 0$ and $A'x + B'y + C' = 0$.

2. Find the equation of a straight line which passes through the intersection of two given straight lines and through a second given point.

The co-ordinates of A, B, C, the angular points of a triangle are (2, 5), (3, − 2) and ( − 3, 4). Find the equations of the lines joining A, B, C to the middle points of the opposite sides, and show that these lines meet in a point.

3. Find the equation of the tangent to the circle $x^2 + y^2 = a^2$, at the point $(x', y')$ Interpret the equation arrived at, when $(x', y')$ does not lie on the circle.

If apoint A lie on the polar of B with respect to the circle $x^2 + y^2 = a^2$, show that B lies on the polar of A.

4. Investigate the equation of the normal to a parabola in the form $y = mx - 2am - am^3$.

From a point P three normals are drawn to a parabola, so that the sum of their inclinations to the axis is constant. Show that the locus of P is a straight line.

5. Find the locus of the middle points of a system of parallel chords of a parabola.

If the chords, instead of being parallel, all pass through a fixed point, the locus of their middle points is a parabola.

6. The two parabolas $y^2 = ax$ and $x^2 = by$ will cut each other at an angle $\tan^{-1} \dfrac{3a^{\frac{1}{3}} b^{\frac{1}{3}}}{2\,(a^{\frac{2}{3}} + b^{\frac{2}{3}})}$.

7. Find the equation of the tangents to an ellipse, which make a given angle with the axis of $x$.

If two tangents to an ellipse meet at right angles, find the locus of their point of intersection.

8. If any point on the ellipse be represented by $x = a \cos \phi$, $y = b \sin \phi$, give a geometrical interpretation of $\phi$.

Find the value of $\phi$ at the positive ends of the latera recta of $3x^2 + 4y^2 = 12$.

9. In the ellipse show that the normal at any point is a fourth proportional to the perpendiculars on the tangent from the centre and the two foci.

10. The distance of a point from the centre of a rectangular hyperbola varies inversely as the perpendicular distance of its polar from the centre.

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## Geodesy.

*Examiner.*—Mr. D. B. Horn.

1. Construct a scale of 16 inches to a mile to read to 10 feet. What is its representative fraction?

2. What is the length of Gunter's chain, and why is it used for land surveying? As a measuring chain is not always of correct length, what tests would you adopt to ensure accuracy of measurement?

3. Explain the principle of the Vernier. The lower plate of a theodolite is graduated to half degrees. Construct a vernier to read to minutes.

4. What is the meaning of the terms 'bearing' and 'angle'? Show how to run a road traverse with theodolite, describing carefully how you would observe the angles. Give form of field book.

5. The radius of a curve connecting two straight lines is half a mile. You are required to lay out the curve by means of offsets at every hundred feet; calculate also the length of offset.

6. Explain and illustrate the meaning of the terms bench mark, datum line, reduced level, curvature and refraction.

7. Obtain an expression for curvature and show how it can be eliminated in levelling.

8. Supposing you were asked to make a longitudinal section of a canal with a dumpy level, what tests would you adopt to ensure that your instrument was in perfect adjustment? Give form of field book.

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## Materials of Construction.

*Examiner.*—Mr. D. B. Horn.

1. Give the three classes into which building stones are generally divided, with examples of each.

2. Show how you would select a good earth for brick-making. Describe briefly the various operations for making slop moulded bricks.

What is the size of an ordinary brick, and what would you specify as the characteristics of a good brick?

3. Explain the difference of composition of a fat lime, and an eminently hydraulic lime.

4. What is meant by hardening? and show how it takes place (1) in an ordinary mortar, (2) in a hydraulic mortar.

5. What are the uses of mixing sand or soorkhee with lime? Would you show any preference if the cost were the same?

6. Give the quantities of materials measured dry to make a hundred cubic feet of ordinary concrete. Describe briefly the operations of mixing and laying the materials.

7. Give some examples of the timbers generally used in India. What are the characteristics of good timber?

8. Explain the terms natural and artificial seasoning. Give examples of each.

9. Describe the process of manufacture of pig-iron. Give a sketch of a blast furnace.

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## CHEMISTRY.

*Examiner.*—MR. A. PEDLER, F.C.S., F.R.S.

1. A solution containing 20 grams of hydrochloric acid is allowed to act on 10 grams of sodic carbonate. State exactly the weights of all the substances produced in the reaction (Na=23).

2. The following are the compositions of five compounds of nitrogen and oxygen. Explain very clearly how you can deduce the law of chemical combination in multiple proportion from these compounds—

| | I | II | III | IV | V |
|---|---|---|---|---|---|
| Nitrogen ... | 63·71 | 46·75 | 36·91 | 30·51 | 25·99 |
| Oxygen ... | 36·29 | 53·25 | 63·09 | 69·49 | 74·01 |
| | 100·00 | 100·00 | 100·00 | 100·00 | 100·00 |

3. A current of oxygen is passed over the following metals when heated to bright redness. State (*a*) what physical changes in the conditions of the metals will happen, and (*b*) what chemical changes; and in the latter case express the changes by equations:—Tin, zinc, lead, copper, iron, sodium, gold, platinum, mercury, nickel, arsenic, silver and magnesium.

4. What is meant by combustion in its widest sense, and what conditions are necessary to bring it about? How can the heat of combustion of such a substance as coal be determined?

A heap of oily rags, or a cargo of jute or coal kept in a confined space may sometimes undergo "spontaneous combustion." Explain this.

5. It is desired to prepare enough oxygen to fill a gas-holder of 100 litres capacity, the temperature being 7°C. and the pressure

742 m.m. How much of a mixture of 3 parts of potassic chlorate and 1 part of manganese dioxide must be heated to prepare it? (K=39.)

6. How is nitric acid prepared and what are its properties? What is the action of nitric acid on copper, tin, zinc, iron, quartz (or silica) and silver? and what is the action of a mixture of nitric and hydrochloric acids on gold, platinum, quartz and diamond?

7. How can a jar of pure ammonia gas be prepared and collected, and what are its properties? Explain the formation of ice in an ammonia ice machine.

8. A lump of chalk is heated to redness in a closed vessel and then allowed to cool and afterwards it is heated in a current of air for some time. State exactly what will happen in each case and explain the results. Compare these actions with the decomposition of potassic chlorate by heat.

9. Describe how a porcelain jar and a sheet of window glass can be manufactured, and state what ingredients are used to prepare them.

10. How would you detect the presence of ammonia, lead salts, copper salts, nitrates, sodium chloride, and organic matter in a sample of drinking water? What conclusions would you draw as to the advisability of drinking water which contained either one of these impurities?

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## Heat and Light.

*Examiner.*—Mr. A. Pedler, F.C.S., F.R.S.

1. Explain clearly how the absolute expansion of mercury by heat was determined by Dulong and Petit and by Regnault, and show how from this we can deduce the expansion of such substances as Iron, Platinum or Glass.

2. Describe Bunsen's Ice Calorimeter and explain its use by an example. What is meant by atomic and molecular heats of substances and what laws govern them?

3. One pound of hydrogen in burning in oxygen produces heat sufficient to raise 34,462 pounds of water through 1°C. Calculate the theoretical temperature of hydrogen burning, (*a*) in oxygen and (*b*) in air (containing 23 pts. by weight of O and 77 pts. by weight of N) both at first at 0°C. (Heat of evaporation of water=606 units; specific heat of water vapour=0·475 and specific heat of N.=0·2438).

4. Describe the construction and use of Daniell's and Regnault's Hygrometers and of the Psychrometer and explain the principles on which they act.

5. What is the effect of increased and decreased pressure on the boiling point of liquids and on the melting point of solids? Contrast the behaviour of water in this respect with that of most other substances and state on what principles these facts are explained. Are these facts connected with any natural phenomena.

6. Describe the general construction of a locomotive engine and contrast its action with that of a condensing engine. Which is more

economical in its action and why? Trace clearly the source of the power in a locomotive engine.

7. Describe the construction and use of a sextant and prove the principle of its action.

8. The rays of the sun are received upon a large converging lens, the focus being visible by the dust floating in the air. A screen placed in front of the focus shows a white circle surrounded by a red fringe, beyond the focus it shows a white circle with a blue fringe. Explain these appearances and show how in an ordinary astronomical telescope these appearances are corrected.

9. Explain how it is proved by the spectroscope that sodium, hydrogen, etc., are present in the sun, and also how it can be shown by the same instrument that certain stars are moving towards, and certain others away from the earth.

10. A beam of light passed through a prism of Iceland spar produces two images. A small piece of tourmaline placed in a certain position in the path of the beam appears opaque in one image and transparent in the other. Explain the cause of these appearances as clearly as you can.

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## Electricity, Magnetism and Telegraphy.

*Examiner.*—Mr. A. Pedler, F.C.S., F.R.S.

1. It is generally stated that electricity resides only on the external surface of a conductor. Mention several experiments which support this. Are there any limitations of this rule? If so, mention experiments which prove the fact.

2. State what materials you would require and how you would prepare an electrophorus? Explain how you would generate electricity from it and how you would test the nature of the electricity obtained from it. What is the precise source of the energy of the electricity thus obtained.

3. Describe the construction of the batteries devised by Leclanché and Minotto, and explain what changes occur when they are worked. Whence comes the energy given out by these batteries?

4. If the external resistance of a battery is small, how will you connect the cells to obtain the greatest current strength, and how would you connect them when the external resistance of the battery is great? Prove the statements you make as far as you can. How would you compare the electromotive force of cells of different forms of batteries?

5. Describe some form of Storage battery with which you are acquainted. Show how it is possible for electricity to be stored up in such a battery, and trace out exactly the changes which occur in the battery, first when it is being charged from a dynamo, and second when it is being discharged.

6. The magnetic power of a bar magnet appears to be concentrated at its ends or poles. Is this concentration real. If not, how is the magnetism distributed? How would you experimentally show your statements are correct?

7. Describe the Bifilar and Balance Magnetometers; explain how they are used and state the purposes for which they are employed. Give a brief statement of what is known as to the distribution of the earth's magnetism.

8. State clearly the principles according to which electric currents are generated by the relative motion of a magnet and a conductor, and describe briefly some simple machine in which these principles are applied.

9. Describe Siemen's Relay, and point out clearly its action when in use in telegraphy.

10. What is meant by Duplex Telegraphy? Explain briefly the two methods in use and the principles on which they depend.

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## Drawing.

*Examiner.*—Colonel A. D. McArthur, R.E.

(The figures should not be inked in and all construction lines must be left. Marks will be awarded for neatness in drawing.)

1. Without the aid of a protractor construct on separate bases of 3 inches in length the following figures:—Square, Rhombus with angle of 60°, and Isosceles Triangle with angle at base 75°.

2. Construct a square equal in area to the isosceles triangle in question 1.

3. Construct a rectangle of which two opposite sides should be $2\frac{1}{2}$ inches in length equal in area to a square of 2 inches side.

4. Make a scale of knots comparative to a scale of 10 miles = 1 inch.

knot = 1·15 miles.

5. Draw the horizontal and vertical projections of a line $1\frac{1}{2}$ inches in length:—

*1st.*—When it is parallel to both planes.

*2nd.*—When it is parallel to the horizontal and perpendicular to the vertical plane.

*3rd.*—When it is inclined at an angle of 45° to both planes.

*4th.*—When it is inclined 45° to the vertical plane and its horizontal projection is inclined 35° to the trace of the two planes.

6. Draw the horizontal and vertical projections of a right pyramid with a hexagonal base of $\frac{3}{4}$ inch side and height of 3 inches resting on one of the sides of the base, the base being inclined 75° to the horizontal plane, and the horizontal projection of the axis inclined 30° to the vertical plane.

7. Develop the surfa e of a pyramid of the dimensions given in the last question.

8. Draw the isometrical projection of a hexagonal column 4 inches in height and $\frac{3}{4}$ inch side of hexagon. The figure should be drawn to isometric scale which mu t be constructed.

# ENGINEER DEPARTMENT.

## L.E. AND B.E. EXAMINATIONS.

### Differential and Integral Calculus.

*Examiner.*—Mr. J. H. Gilliland, B.A.

1. Define a "differential coefficient" and show from your definition that if $u$ and $v$ be functions of $x$ and $y=uv$, then

$$\frac{dy}{dx} = v\frac{du}{dx} + u\frac{dv}{dx}$$

Differentiate with respect to $x$ the functions $(a+bx+cx^2)^2$,

$$\sqrt{\frac{a^2-x^2}{a^2+x^2}} \text{ and } \log\left(x+\sqrt{1+x^2}\right).$$

2. Enunciate and prove Leibnitz's Theorem for the $n^{th}$ differential of the product of two variables.

If $y=x^3 \cdot \log x$, find $\frac{d^4y}{dx^4}$.

Given $y=\log_b(a+x)$, show that

$$\frac{d^ny}{dx^n} = (-1)^{n-1}\cdot\frac{\underline{/n}}{\log_b (a+x)^n}.$$

3. Evaluate the interminate expressions.

$$\frac{a^{\sin x}-a}{\log(\sin x)} \text{ when } x=\frac{\pi}{2}, \quad \frac{x\sqrt{3x-2x^4-x^5}}{1-x^4} \text{ when } x=1,$$

$$\frac{x^2-a^2}{a^2}\tan\frac{\pi x}{2a} \text{ when } x=a.$$

4. State Maclaurin's Theorem and employ it to expand $a^x$ and $\frac{\sin x}{1-x}$ as far as $x^4$.

5. Show that if $\phi(x)$ be a maximum when $x=a$, then $\phi'(a)=0$ and $\phi''(a)$ is negative.

Determine the maximum volume of a cone of given slant height, $l$.

6. Explain the process called "Integration by parts" and employ it to obtain the values of $\int \cos^{-1} x.\, dx$ and $\int x^3.\, \cos x.\, dx$.

7. Evaluate $\int \frac{x dx}{(x+2)\ (x+3)}$ and $\int \frac{x^2.dx}{(x-1)^2\,(x^2+1)}$.

8. Find a form of reduction for $\int \sin^n \phi.\, d\phi$, and show that

$$\int_0^{\frac{\pi}{2}} \sin^{2m} \phi.\, d\phi = \int_0^{\frac{\pi}{2}} \cos^{2m} \phi.\, d\phi = \frac{1.\,3.\,5.....(2m-1)}{1.\,4.\,6.....2m} \cdot \frac{\pi}{2}$$

9. Find an expression for the length of the arc of a plane curve whose equation is given in rectangular co-ordinates.

Determine the length of the arc (measured from the origin) of the curve $y = a \log \frac{a^2-x^2}{a^2}$.

10. Apply the method of Integration to determine the whole area of the ellipse.

Find the area betwen the curve $xy^2-2ay^2+4a^2x=0$ and its asymptote ($x=2a$).

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## Hydrostatics.

*Examiner.*—Mr. J. H. Gilliland, B.A.

1. Define "pressure at a point" in a fluid and show how it is measured when variable. Show that it is the same in all directions.

The cylinders of an hydraulic press are 1″ and 2′ 6″ in diameter; the arms of the lever 4″ and 3′ 6″. What pressure will be supplied by a boy who presses the handle of the lever down with a force of 10 lbs.?

2. Prove the formula $p=g\rho z$.

Find the pressure at a depth of 50 feet in sea-water, when the barometer stands at 30″; given sp. gr. of mercury = 13·568, sp. gr. of sea-water = 1·035.

3. Find the position of the common surface of two liquids which meet in a bent tube and do not mix.

Water is poured into a U tube, the legs of which are 12″ long until they are half full. As much oil as possible is then poured into one of the legs. What length of tube does it occupy, the density of oil being two-thirds that of water?

4. Find an expression for the whole pressure of a fluid on a surface immersed in it.

A closed conical vessel, without weight, whose height is twice the diameter of its base, is just filled with water and suspended by a string attached to a point on the rim of its base. Find the whole pressure on its curved surface in terms of the weight of liquid.

5. Define centre of pressure.

A square whose side is 20″ is immersed vertically in a fluid with a side horizontal, to such a depth that the distance of the centre of pressure from the centre of gravity is $1\frac{2}{3}$ inches. Find the depth.

6. Find the conditions of equilibrium of a floating body.

Two solids whose weights are $36\frac{1}{2}$lbs., the volume of the former being three times tha of the latter, are connected by a string passing over a fixed pulley, and rest in equilibrium totally immersed in fluids of sp. gr. 1·07 and 3·05 respectively. Find the volumes of the solids.

7. Describe the experiments by which the formula $p=k\rho$ was established.

What are the "dimensions" of $k$?

A quantity of gas under a pressure of 59 inches of mercury and at a temperature of 81°C occupies a volume of 18 cubic inches; what volume will it occupy under a pressure of 63 inches of mercury and at a temperature of 42°C?

8. Show how to graduate the Common Hydrometer. A Nicholson's hydrometer weighs $4\frac{2}{4}$ oz. and it requires weights of 2 oz. and $.2\frac{2}{8}$ oz respectively to sink it to the fixed mark in two different liquids. Compare the specific gravities of the liquids.

9. Describe Hawksbee's air-pump.

If the capacity of the barrel be $\frac{1}{10}$ of the capacity of the receiver, in which stroke will the density of the air be reduced to half its original density?

10. Three fluids whose specific gravities are 1·56, 1·45 and 1·65 are mixed in the proportion of 5 : 7 : 9 of their volumes respectively. To what depth will a cylinder 10 inches in height and specific gravity 2·1 sink in the liquid?

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## Geology.

*Examiner.*—Mr. A. Pedler, F.C.S., F.R.S.

1. What is the form of the earth? State its density as a whole, and also the average specific gravity of the rocks near its surface. What conclusions do you draw from these facts?

2. Describe the various hypotheses which have been put forward as to the probable condition of the earth's interior, and explain which arguments have the greatest weight.

3. Give the microscopic characters and essential constituents of Dolomite, Hornstone, Granite, Syenite, Pumice, Gravel, Sandstone,

Shale and Laterite, and indicate roughly where such rocks are usually found.

4. What is the action of water (in the liquid form only) as a geological agent, both in the case of denudation and deposition?

5. Mention the principal features which would be looked for to determine whether a country had been previously subjected to the action of glaciers. Which features are most conclusive?

6. Describe clearly the phenomena which usually accompany earthquakes, and state what observations you would make if you experienced an earthquake. If you are called upon to write an account of an earthquake experienced over a large district, what points would you consider it necessary to investigate. Give a brief account of the theories put forward to account for earthquakes.

7. Explain as far as you can the origin and formation of coal, tracing its history through the various intermediate products which may be formed.

8. What is meant by the "Gondwana system" (or series of deposits), and what is its geological position? What is its probable origin?

9. By what process is it supposed that veins of quartz, calc spar, ores of metals and even metals themselves have been formed in lodes.

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## Mineralogy and Metallurgy.

*Examiner.*—Mr. A. Pedler, F.C.S., F.R.S.

1. Describe very briefly the principles of crystallographic notation as proposed by Miller, Weiss and Naumann.

2. What are the principal terms used in describing the cleavage of a mineral? What also are the principal directions of cleavage observed in the different crystallographic systems? If possible give examples of each case.

3. Give a sketch of the subject of isomorphism. Mention several groups of isomorphous bodies, and state which are the isomorphous elements or groups in them.

4. Describe the general characters and give the crystalline form, mode of occurrence and chemical formulæ of the following minerals:—Iron Pyrites, Argentite, Spinel, Tetrahedrite, Arragonite, Barytes and Orthoclase.

5. Name the principal minerals in which Zinc and Tin occur in nature. Give their chemical and mineralogical names and formulæ and their crystallographic form and general characters.

6. Which of the chemical elements occur as minerals in nature? State their modes of occurrence and crystalline form.

7. Describe the English (sometimes called Welsh) and the Mansfeld process for the extraction of copper from its ores.

8. Describe how the metal aluminum is prepared on a manufacturing scale. What modern improvements have been lately made in this process?

9. What is meant by Hydraulic Mining for Gold, and how is it carried out? Describe also Plattner's process for the extraction of gold.

10. Describe in detail Bessemer's process for the manufacture of steel, tracing out the chemical actions which take place, and indicate any improvements which have been introduced since it was first proposed.

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## Details of Construction.

*Examiner.*—Mr. W. Banks Gwyther, A.R.I., B.A., A.M.I.C.E.

(Accuracy and neatness of sketches will be taken into account in awarding marks.)

1. Indicate in pencil on the plans marked A. B. C. and D. in the sheet of illustrations handed to you, the kind of foundations you would provide in each case, supposing these walls were built (i) on ordinary Calcutta soil, and (ii) on solid rock. Calculate what 'spread' ought to be given to wall A if erected on such soil as is referred to in (i).

2. What do you understand by the 'natural bed' of a stone and in what way does it affect the use of this material for constructional purposes? How, for instance, would a projecting stone cornice be affected by the nature of the 'bed.' Describe briefly the methods of stone bonding used in the construction of light-houses in exposed situations.

3. What are the main points to be kept in view in the design of iron girders? Sketch and figure a cross section of an iron plate girder 2½ feet deep for a 30-feet span, and write a specification for it.

4. Supposing you had to construct a continuous wooden balcony projecting 4 feet and covered with a shingle roof, at the first floor level of an existing building; show by means of sketches (i) the general form of construction you would adopt, and (ii) the detailed methods you would employ for fixing the balcony to the building.

5. Describe and illustrate the following, and say under what circumstances they are employed:—corbel, ferrule, wind-tie, shoring, master-trap, Ionic column, Romanes' punkah machine, and arc lamp?

6. On what principles is the present system of protecting buildings from lightning based? What do you know of the several materials employed for the purpose and the manner in which they are used? Give reasons.

7. Design and sketch roughly the plan elevation and section of a small police-station with the following accommodation:—Inspector's room, office, constables' room, waiting room, separate hajuts for male

and female prisoners, store room, and property room. The building to be 'pucka' throughout and to be erected on a corner site where two roads meet at right angles.

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## Roads and Railways.

*Examiner.*—Mr. W. Banks Gwyther, A.R.I., B.A., A.M.I.C.E.

(Neatness and accuracy of sketches will be taken into consideration in awarding marks.)

1. What is a 'macadamized' road and what are its advantages and disadvantages as compared with roads made of stone setts, wood blocks, and brick ballast? Give a specification for a 'macadamized' road 40 feet wide with side paths to be constructed in Calcutta.

2. If you were given the necessary plans and estimates for the construction of a first class road, say 20 miles long, describe exactly what steps you would take from the beginning to carry out the work.

3. Distinguish between the following types of bridges:—suspension, cantilever, floating, lifting, swing and screw-pile. Illustrate them roughly and mention any examples you may know of each type. What are the main features of the Tower Bridge now being constructed over the Thames in London?

4. Give very briefly the history of railway progress in India, noting in somewhat greater detail the present state of Railway communication in Bengal.

5. What are the chief requirements in connection with a 'permanent way'? Sketch to a large scale the outlines of double-headed, Vignoles, bridge and tram rails, and describe the recognized means of laying them to form a roadway.

6. Explain, and where possible, illustrate the following:—siding, level crossing, lock-rail, overbridge, running powers, cant, bogie, adhesion, creep of rails, and gradient.

7. Sketch plan and cross section of a 10-feet railway culvert through an embankment 10 feet high: figure the dimensions, and give reasons for adopting the type you suggest.

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## Hydraulics.

*Examiner.*—Major H. D. Love, R.E.

*Note.—Tables of logarithms and roots may be used. The drawings required in questions* 2, 3, *and* 4 *are to be neat pencil sketches, made to scale, on section paper or otherwise, and fully dimensioned. The answers to the remaining questions should be illustrated by hand sketches.*

1. At the Liverpool Water Works the compensation water to be passed down the surplus channel is delivered into still water tanks. One end of each tank contains a thin edged rectangular opening 3 feet

long and 1 foot deep, the upper sill of which is 1 foot below the top edge of the end of the tank. The water surface in the tank is kept at exactly the level of this top edge. Calculate the discharge from each tank in gallons per day.

2. A channel supplied by a river has a bottom width of 15 feet and side slopes of 1½ to 1. The fall is such that with the full supply depth of 4 feet, the mean velocity is 2½ feet per second. How many vents each 4 feet wide will be required for the head sluice, so that the full supply may be secured when the level of water in the river is at 4 feet 9 inches above the sluice sill, *i.e.*, above channel bed, and the shutters are raised 3 feet above sill? Coefficient of discharge 0·85.

Draw a cross section of half the channel to a scale of 4 feet to 1 inch, and show on it a half elevation of the sluice carrying a roadway. Any assumptions may be made as to nature of soil, natural ground level, &c.

3. A reservoir has a single escape, 120 feet long, whose crest is at the level 30·62. The bed of the surplus channel is at 26·12. The maximum flood supply coming into the reservoir is estimated from the rainfall records to be 1,470 cubic feet per second. The top of the dam is to be 3 feet above maximum water level in the reservoir. What should be the level of the dam top?

Draw a cross section through the escape to a scale of 8 feet to 1 inch, showing the (earthen) dam and wing wall in elevation. Mark in dimensions and levels.

4. A 1,000 feet length of new 14-inch cast-iron pipe main discharges 1,600 gallons per minute. Determine the loss of head in this length due to friction.

Draw a suitable joint for the pipe, scale 2 feet to 1 inch.

5. Indicate the mode in which you would determine the diameters of the different pipe lengths in the following cases for a required discharge of 1,000 gallons per minute. The formulæ employed should be shown, but numerical results are not required.

| | Feet. | | Feet. |
|---|---|---|---|
| (*a*) Head over inlet ... | 4 | (*b*) Head over inlet ... | 4 |
| Fall in first 1,000 ft. ... | 8 | Fall in first 1,000 ft. ... | 1 |
| Rise in second 1,000 ft. | 1 | Fall in second 1,000 ft. | 8 |

6. Design a channel section in earth to carry a discharge of 400 cubic feet per second. The velocity is to be 2 feet per second, the fall 1 in 3,600, and the side slopes 1 to 1. The appropriate value of $c$ in the expression $v = c\sqrt{rs}$ can be taken from the following table:—

| $r$ | 2·0 | 2·2 | 2·4 | 2·6 | 2·8 | 3·0 | 3·2 | 3·4 | 3·6 | 3·8 | 4·0 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $c$ | 62 | 64 | 66 | 68 | 69 | 70 | 72 | 73 | 74 | 75 | 76 |

7. The accompanying drawing shows in section a Poncelet wheel having a peripheral velocity of 9·33 feet per second. Draw *on the section*, from the point A, one of the curved wheel vanes, and give reasons for the method you adopt. Determine the breadth of the wheel, the

depth of the shrouding, and the velocity and direction of the water when it finally leaves the vane.

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## Applied Mechanics.

*Examiner.*—Major H. D. Love, R.E.

*Note.—Tables of logarithms or of squares and cubes may be used.*

1. Write down Euler's formula for long compression bars, explaining the meaning of the different symbols.

A wrought iron pillar, 15 feet long, fixed firmly at both ends, is of the section shown in figure 1. Find, by Gordon's formula or otherwise, the greatest load which can be placed on it so that the stress may not exceed 4½ tons per square inch. The ultimate strength of the material in compression is 18 tons.

2. Find the moment of inertia of the Tee section shown in figure 2, about the axis AB passing through the centre of gravity G of the section.

If two steel bars of this section are laid side by side, head downwards, across a span of 10 feet, find the maximum distributed load they would carry without developing a greater direct stress than 7½ tons per square inch.

3. In the case of a supported beam with a uniform rolling load of greater length than the span, state the position of the load which makes the shearing stress due to it, at a given section, a maximum.

A Warren girder, figure 4, is 64 feet long and 4 feet deep, with bracing at 45°. The top flange is divided into 8 bays, and the bottom flange into 7 bays, each of 8 feet. The rolling load on the girder is 1 ton per foot run, carried on the top flange. The dead load is ½ ton per foot run, carried half (approximately) on each flange. Find the maximum stress in—

(*a*) the fifth diagonal from one end of the girder,
(*b*) the third bay of the top flange.

4. Roof trusses of the form shown in figure 3 are 30 feet span, 10 feet apart, and carry a vertical load of 20lbs. per square foot of roofing. The rise is 10 feet, camber 3 feet, middle segment of tie 10 feet, segment of rafter each 9¼ feet. Draw a stress diagram to a scale of 1,000lbs. to 1 inch, assuming the joints to be free, and the load applied of the joints. Mark on each bar of the frame the nature and amount at the stress it bears.

If you were designing the truss, what amount and direction of wind pressure would you allow on each of the segments of the rafter?

5. Find the general equation to the elastic curve of a beam loaded transversely within the limit of elasticity; and thence determine the deflection of the steel bars referred to in question 2. Modulus of direct elasticity of steel 30,000,000lbs.

*Fig. 1.*

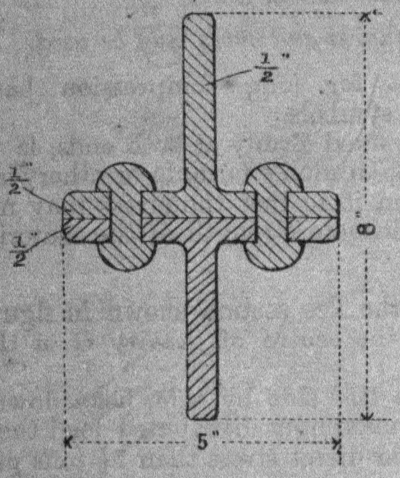



*Fig. 2.*

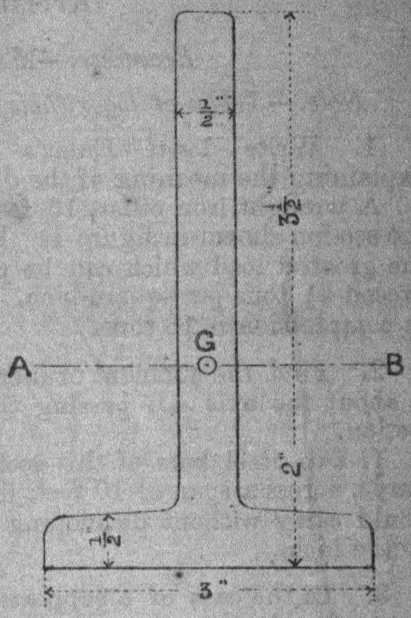



*Fig. 3.*

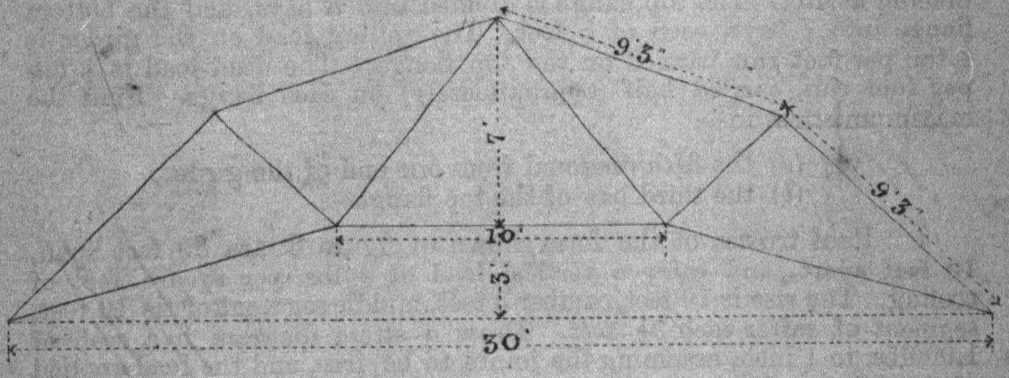
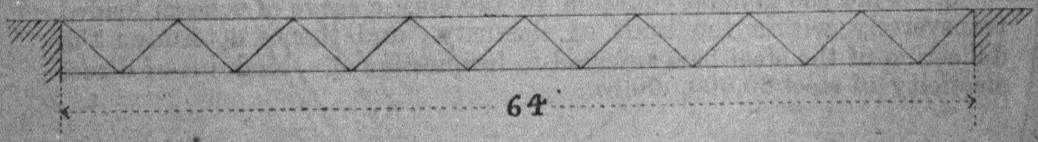



*Fig. 4.*



6. In a compression member (such as an arch rib) of rectangular cross section, strained within the elastic limit, the condition that no fibres shall be in tension requires that the line of resultant thrust must lie within the middle third of the depth of the rib. Prove this.

A wall 24 feet high, 3 feet thick at top, and 12 feet at bottom, weighing 125lbs. per cubic feet, sustains water pressure on its vertical face Find the point at which the line of resistance cuts the lowest bed-joint, and thence determine the stress intensities per square inch, normal to the bed-joint at the inner and outer toe respectively of the wall.

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## Mechanism and Steam Engine.

*Examiner.*—Mr. D. B. Horn.

1. What is a 'Cam'? Give some examples of its application.

2. Illustrate with sketches any systems of reversing motion with which you are acquainted.

3. Construct a pair of speed pullies to give two extreme velocity ratios of 7 to 1 and 3 to 1. The belt is to be crossed and the least permissible diameter is 5 inches.

4. What is the use of belting? Give some of the various kinds of belts used. Show how to connect by means of belting two shafts which are at right angles?

5. What is Joule's equivalent? How many heat units are equivalent to raising 3 tons of water through 500 feet?

6. Define Horse-power. How many cubic feet of water will an engine of 10 H. P. raise from a depth of 150 feet in 24 hours.

7. Explain what is meant by working steam expansively. Assuming that volume of steam varies inversely as pressure obtain an expression for work done in one stroke of the piston.

8. Explain the principle of the injector, and describe any form of it which you may know.

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## Drawing.

*Examiner.*—Col. A. D. McArthur, R.E.

*Five only of these questions should be attempted, for which full marks may be given. No construction lines whatever should be rubbed out and no inking in is required. In every case marks will be allotted for neatness of drawing.*

1. Divide a triangle into two equal parts by a line parallel to one of its sides.

Draw a circle which shall touch the two lines of a given angle, and pass through a point within the angle.

2. Taking the horizontal and vertical projections of any two points so that the straight line joining them is not perpendicular or parallel to either plane, find the correct length of the line and its angle of inclination to one of the planes.

3. Draw the horizontal and vertical projections of a right prism, 4 inches in length with a regular pentagonal base of one inch side, resting on a point of its base on the horizontal plane, the axis being inclined to the horizontal plane at an angle of 30°, the horizontal projection of the axis being inclined at the same angle to the trace of the two planes.

4. Explain clearly the principle of Isometrical Projection. Construct the isometric scale, and show geometrically the reasons for the method of construction.

5. Given the traces of a plane inclined to both horizontal and vertical planes and the projections of a point above it, drop a perpendicular from the point to the plane showing its point of contact with the plane.

6. A cylinder with a diameter of base of 1 inch cuts the prism as projected under the conditions of question 3, so that the axis of the cylinder is in the same plane with and cuts the axis of the prism at right angles. Draw the section.

7. A sphere of 2 inches diameter raised one inch above the horizontal and one inch from the vertical plane is intersected by a plane inclined 45° to the horizonal plane and inclined also to the vertical plane. Draw the correct section and show the point of contact with the sphere of a plane parallel to the cutting plane and touching the sphere.

8. A regular 5-sided prism rests on one of its rectangular faces, the sides of which are inclined at 45° to the picture line. The edges of the pentagonal faces measure 4 feet and the length of the prism is 10 feet. The nearest corner of the base is 4 feet to the left of the central line and 1 foot within the picture. Draw the perspective of it. Height of eye, 8 feet, distance 14 feet.

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*Optional Paper.*

MATERIALS OF CONSTRUCTION.

*Examiner.*—MR. D. B. HORN.

1. In what class of works would you use granite? What are the causes which lead to the decay of sandstone in buildings? Describe any of the processes which have been tried for the preservation of perishable stone.

2. Give examples of the "bonds" used in brickwork. Draw up a specification for first class brickwork to be laid in hydraulic mortar.

3. Draw out a specification for Portland cement concrete such as is generally used in dock walls.

4. What are the causes which tend to the decay of timber? In what class of works are oak, elm, greenheart, and teak generally used? Describe some of the methods employed for the artificial seasoning of timber.

5. Describe briefly the process of manufacture of wrought iron and give sections of the ordinary sizes procurable in the market.

6. Describe fully the distinctive characteristics of wrought and cast iron, and show how they would guide you to the employment of the respective metals.

7. What are the working stresses of wrought iron? The maximum stress at the centre of span of a lattice girder is 100 tons; give a cross section of the top and bottom boom; also show the form of joint you would use.

8. Sketch and describe some of the joints used in carpentry. Make a drawing of a built teakwood beam for a span of 30 feet, the beams to be placed 5 feet apart; the weight to be carried may be assumed at 120 lbs. per square foot.

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*Optional Paper.*

GEODESY.

*Examiner.*—MR. D. B. HORN.

1. Construct a scale of 32 inches to a mile to read to 10 links. What area does one square inch represent?

2. Construct a vernier for a barometer to read to thousandths of an inch.

3. Describe Gale's system of traverse: show how to plot the work, and what conditions must be fulfilled when the traverse makes a complete circuit?

4. Describe the permanent adjustments of the Dumpy level. Fill in imaginary levels for about half a mile of longitudinal section of canal: show how to plot the work, and say what scales you would use?

5. Show how to lay out a curve:

(i) By means of theodolite.
(ii) By offsets from the chords.

6. The lantern of a lighthouse is 170 feet above sea level: at what distance out at sea would the light be visible?

7. Explain the meaning of the terms declination, right ascension, longitude, latitude, mean time, and sidereal time.

8. Show how to determine accurately the true meridian. Also state how the same may be approximately ascertained.

*Optional Paper.*

PHYSICS.

*Examiner.*—MR. A. PEDLER, F.C.S., F.R.S.

1. You have given you two bar magnets of different powers and also a freely suspended magnetic needle. Show how you would experimentally determine the relative strengths of the two magnets, and explain on what principles your experiments are based?

2. An electric current from a battery is passed through some water acidulated with sulphuric acid. State precisely what happens and how the phenomena can be explained? If 65 grains of zinc are consumed in a battery, and the current produced is passed successively through solutions of Hydrochloric Acid, Copper Sulphate and Ferric Chloride, what will be the weights of these substances acted on, on the assumption that all the electricity generated acts on these bodies?
Cl. = 35·5, Cu. = 63·5, Fe. = 56, S = 32, O = 16, Zn. = 65.

3. Explain clearly what is meant by an Electrical Condenser, and describe the construction and use of any well-known form?

4. Describe clearly what arrangements you would make to erect and work a single needle Telegraph, and explain carefully the principles on which such instruments work, and in what circumstances these instruments are employed?

5. Describe Holtz's Electrical Machine, and explain how it is worked?

6. Describe Bunsen's Photometer, and show how it is used to determine the luminosity of any source of light? How many candles are required to produce at a distance of 50 yards the same illuminating effect as two candles at 5 yards?

7. Describe as far as you can the construction of a compound microscope, and explain the principles on which it depends.

8. What is meant by the Interference of Light, and show how you would experimentally demonstrate it? Describe how a pure spectrum can be obtained by the use of a diffraction grating.

9. Describe the construction of an ordinary mercurial thermometer, and show how you would graduate it? Explain also the construction of a maximum and of a minimum thermometer, and show how they are used.

10. Give a short account of the absorption of radiant heat by gases and vapours, and sketch an apparatus which might be used to show these effects. Have the facts discovered any bearing or influence in modifying the temperature of an atmosphere?

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*Optional Paper.*

CHEMISTRY.

*Examiner.*—MR. A. PEDLER, F.C.S., F.R.S.

1. Describe clearly what is meant by the term Chemical Valency or Atomicity. Is this a fixed and definite quantity in elements; if not,

how is the variation explained? Explain your remarks by reference to the compounds of such elements as Nitrogen, Sulphur, Tin and Gold.

2. A sample of water contains in solution calcium hydrogen bicarbonate, magnesium carbonate (dissolved in carbonic acid), sodium sulphate, and sodium chloride; another sample of water contains calcium sulphate, magnesium chloride, sodium sulphate, and sodium chloride; and a third sample sodium sulphate, sodium chloride and sodium carbonate. Which of them would be *hard* and which *soft waters?* Also, what would be the effect of boiling these waters and of using each sample of water in a steam-boiler? Which water would be most suitable for washing with soap, and why?

3. Explain clearly the formation of nitre or potassium nitrate in soil, and its appearance on the surface as an incrustation. What other substances are known to form incrustations on soils or damp walls of houses?

4. How can silicon be prepared; what are its properties? How many oxides and acids of silicon are there, how can they be obtained, and in what form?

5. How can Marsh Gas or Fire Damp be prepared, and what are its properties? How much air and how much oxygen will be required to produce an explosive mixture with it? How can the occurrence of Marsh Gas and Fire Damp in nature be explained?

6. In what compounds does the metal aluminum occur in nature and how can the metal be extracted? What are the properties of aluminum? Show that its properties would render this one of the most commonly used metals, if it could be obtained cheaply.

7. Describe briefly the metallurgy of Zinc. What are the properties of the metal? How is galvanized iron made? Contrast the properties of this substance with those of Tin plate.

8. Give the tests you would apply to determine whether a substance contains Au. Ag. Cu. Fe. or Pb.

9. Describe the manufacture of white lead and of lead chromate.

10. Give a brief description of what is meant by the term chemical affinity or chemical attraction, and show in what way it differs from the other physical forces. What conditions influence chemical affinity?

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*Optional Paper.*

MIXED MATHEMATICS.

*Examiner.*—MR. J. H. GILLILAND, B.A.

1. Prove the "polygon of forces."

Five equal forces (P) acting at a point are represented in direction by AB, BC, CD, DE, EF, five sides of a regular octagon. Find the magnitude and direction of their resultant.

2. Find the resultant of two "unlike" parallel forces. A tricycle weighing 5st. 4lbs. has a small wheel symmetrically placed 3 feet behind two large wheels, which are 3 feet apart. If the Centre of Mass of the machine be 9 inches behind the front wheels, and that of the rider (who weighs 9st.) be 3 inches behind, find the pressures on the ground of the 3 different wheels.

3. A uniform ladder rests on a rough horizontal floor and against a rough vertical wall. If the coefficient of friction for the ladder and the ground be $\frac{1}{4}$, and that for the ladder and the wall be $\frac{1}{3}$; find the angle which the ladder makes with the ground when it just begins to slide.

4. A uniform lamina in the shape of a right-angled triangle having one of the sides containing the right angle three times the other, is suspended by a string attached to the right angle. Prove that in the position of equilibrium, the hypotenuse makes an angle of $\sin -1\frac{3}{5}$ with the vertical.

5. Find the relation between the power P and the weight W in a system of 5 moveable pulleys, in which each pulley hangs by a separate string, and the weight of each pulley is equal to P.

6. Supposing, in question 5, that we replace the power P by a power 4 P; find the resultant accelerations of the 4 P and W.

7. A train weighing 75 tons ascends an incline of 1 in 800 with a uniform velocity of 40 miles per hour. Assuming that the resistances due to friction, etc., are equivalent to 6lbs. per ton of the train's mass, find, approximately, the rate at which the engine is working.

8. A man can throw a cricket-ball 48 yards vertically upwards. Find the greatest distance he can throw it on a horizontal plane, assuming the initial velocity to be the same.

9. If a cricket-ball, having a coefficient of elasticity $= \frac{1}{3}$, fall from a height of 48 yards on a stone pavement, find the height to which it will rebound, and the time before it ceases to rebound.

10. A train travels at the rate of 40 miles per hour; find how much the outer rail must be raised on a curve of half a mile radius, the gauge being 4 feet, so that there shall be no side thrust on the flange.

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*Optional Paper.*

PURE MATHEMATICS.

*Examiner.*—MR. J. H. GILLILAND, B.A.

1. On a certain railway line the telegraph posts are placed 58 yards apart, and a traveller counts as he passes 37 posts in two minutes; at what rate is he travelling.

2. Solve the equations $\frac{x-a}{x-b}+\frac{x-b}{x-c}+\frac{x-c}{x-a}=3$,

$$\begin{cases} x^2 + 2xy = 39 \\ 2y^2 - 3xy = 5. \end{cases}$$

3. M and N are the sums of $m$ terms and $n$ terms respectively of an A. P. whose first term is $a$, prove that

$$\frac{n-1}{m}\mathrm{M} - \frac{m-1}{n}\mathrm{N} = (n-m)\,a.$$

Apply this formula to find an A. P., the sum of 20 terms of which is 80, and of 30 terms is 1,020.

4. If $n$ be a positive integer and

$$(1+x)^n = p_0 + p_1x + p_2x^2 + \ldots\ldots + p_nx^n,$$

show that $p_0^2 + p_1^2 + p_2^2 + \ldots\ldots + p_n^2 = \frac{\lfloor 2n}{\lfloor n \cdot \lfloor n}$.

5. Show that (i) $2\sin\theta - \sin 5\theta + \sin 3\theta = 16\sin^3\theta \cdot \cos^2\theta$.

(ii) $\tan^{-1}\frac{2-\sqrt{3}}{3} + \tan^{-1}\frac{2\sqrt{3}-1}{\sqrt{3}} = \frac{\pi}{3}$.

6. $x$, $y$, $z$ are the respective perpendiculars from the angular points A, B, C of the triangle ABC on the opposite sides; $r_a$, $r_b$, $r_c$ the radii of the escribed circles, show that

$$\frac{1}{x} + \frac{1}{y} + \frac{1}{z} = \frac{1}{r_a} + \frac{1}{r_b} + \frac{1}{r_c} = \frac{1}{r}.$$

7. Show that if perpendiculars be drawn from he vertices of a triangle to the opposite sides, they will meet in a point (the orthocentre).

A straight line of given length slides between the legs of a fixed angle; find the locus of the orthocentre of the triangle thus formed.

8. Tangents to a parabola at the extremities of a focal chord intersect at right angles on the directrix.

From a point O on the directrix of a parabola are drawn two tangents, and through the focus S, two straight lines parallel to these tangents. The part of the directrix intercepted between these parallels shall be bisected at O.

9. Find the equation of the tangent at any point of the parabola whose equation is $y^2 = 4ax$.

Prove that the parabolas $x^2 + 4a(y - 2b - a) = 0$ and $y^2 = 4b(x - 2a + b)$ cut at right angles at a common end of a latus-rectum of each.

10. If the eccentric angles of two points on an ellipse

$$\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1 \text{ be } \theta - \phi \text{ and } \theta + \phi,$$

prove that the tangents at these points will meet in the point whose co-ordinates are $a\cos\theta\sec\phi$, $b\sin\theta\sec\phi$.

# ENGINEER DEPARTMENT.

*List of Bachelors and Licentiates in Engineering of the Calcutta University.*

| | B.C E. | Year. | Present or last appointment. |
|---|---|---|---|
| | Kali Podo Sen ... | 1870 | Assistant Engineer, Public Works Department. |
| | A. G. Bremner ... | 1872 | Dead. |
| | J. C. Rees | 1872 | Executive Engineer, Burma Ruby Mines. |
| | Netye Govindo Chowdhury .. | 1873 | District Engineer, Monghyr. |
| 5 | Hari Das Pal | 1875 | District Engineer, Burdwan. |
| | Nobin Chandra Gupta ... | 1875 | ..... |
| | Sasi Bhusan Mehir .. | 1875 | District Engineer, Dacca. |
| | Ambica Charan Bose ... | 1875 | ..... |
| | Mohendro Nath Sen ... | 1876 | Dead. |
| 10 | Nagendro Nath Chatterjee ... | 1876 | ..... |
| | Asutose Lahiri | 1876 | District Engineer, Rangpur. |
| | Atul Krishna Mookerjee .. | 1877 | District Engineer, Dinajpur. |
| | Gagan Chandra Biswas . | 1877 | District Engineer, Jalpaiguri. |
| | Behari Lal Rajack ... | 1877 | ..... |
| 15 | Jogodish Chandra Ray .. | 1877 | District Engineer, Lohardaga. |
| | Suresh Chandra Ganguly .. | 1878 | Overseer, Public Works Department. |
| | Bhut Nath Chattopadhyay ... | 1879 | Assistant Engineer, East Coast Railway, Madras. |
| | Upendro Nath Chattopadhyay | 1879 | Pleader, Monghyr Bar. |
| | Bama Charan Sen .. | 1880 | Supervisor, Public Works Department. |
| 20 | Surendro Kumar Bose .. | 1880 | Teacher, Civil Engineering College, Sibpur |
| | Upendro Nath Bandyopadhayay | 1880 | District Engineer, Birbhum. |
| | Annadaprosad Sircar ... | 1883 | Assistant Engineer, 1st grade, Orissa. |
| | Hari Pada Ghosal ... | 1883 | Builder and Contractor, Calcutta. |
| | Rajendranath Mukhopadhyay | 1883 | Overseer, 1st grade, 2nd Calcutta Division. |
| | B.E. | | |
| | Sorabji Shavaksha ... | 1886 | Assistant Engineer, 1st grade, Public Works Department, Buxar. |
| | Beni Madhab Mittra ... | 1887 | Assistant Engineer, 2nd grade, Public Works Department, Sone Circle |
| | Nogendra Nath Mukhopadhyay | 1888 | Assistant Engineer, 3rd grade, Public Works Department, Orissa |
| | Satish Chandra Chattopadhyay | 1889 | Overseer, 2nd grade, Public Works Department, Singhbhum. |
| 5 | Adhor Lal Chandra .. | 1889 | Calcutta Municipal Corporation. |
| | J. B. Godfrey ... | 1890 | Temporary Assistant Engineer. |
| | Po Thoung ... | 1890 | Unknown. |
| | Khirode Chandra Mukerjee .. | 1890 | 2nd grade Overseer. |
| | Haridas Ganguli ... | 1890 | Ditto. |
| 10 | Giris Chandra Das ... | 1891 | Overseer, Public Works Department. |

| | B.E.—*concluded.* | Year. | Present or last appointment. |
|---|---|---|---|
| | Mohini Mohan Lahiri ... | 1891 | Overseer, Public Works Department. |
| | Modhusudhan Sen Gupta ... | 1892 | Practical training. |
| | Surendra Nath Bhattacharji ... | 1892 | Ditto. |
| | C. H Bond ... | 1892 | Ditto. |
| 15 | Saroda Charan Mitra ... | 1892 | Ditto. |
| | L.C.E. | | |
| | M. R. Lackerstein ... | 1867 | Executive Engineer, Public Works Department. |
| | Preo Nath Banerji ... | 1867 | Ditto ditto. |
| | Omerto Lal Ray Chowdhury ... | 1867 | Executive Engineer, Dacca. |
| | Unadi Nath Mookerjee ... | 1867 | Executive Engineer, Eastern Bengal State Railway. |
| 5 | Khetter Nath Ghose ... | 1867 | ..... |
| | Bhuban Mohan Bose ... | 1867 | Executive Engineer, Bareilly, Rampur. |
| | Jogendro Nath Mookerji ... | 1868 | ..... |
| | Kanti Chundra Banerjee ... | 1868 | ..... |
| | Prosonno Coomar Daniary ... | 1869 | Executive Engineer, 4th grade. |
| 10 | Sandam Charn Patnaik ... | 1869 | ..... |
| | Harán Chunder Banerjee ... | 1870 | Executive Engineer, Public Works Department. |
| | Kally Prosonno Mookerji ... | 1870 | Assistant Engineer, 1st grade, Local Works, Hooghly. |
| | Aghore Nath Mookerji ... | 1870 | ..... |
| | Gyan Chandra Ray ... | 1870 | ..... |
| 15 | Wooday Narayan Singh ... | 1870 | ..... |
| | Rakhal Das Chatterji ... | 1871 | Executive Engineer, Public Works Department. |
| | Kally Sunker Chatterji ... | 1871 | Ditto. |
| | Kerty Chunder Chowdhury ... | 1872 | Assistant Engineer, 1st grade. |
| | Chander Mohan Ray ... | 1872 | ..... |
| 20 | Dhurroney Dhor Banerji ... | 1872 | District Engineer, Ghogipur. |
| | W. P. Milne ... | 1872 | Executive Engineer, B. R. M. Railway. |
| | J. R. Swinden ... | 1872 | Executive Engineer, 3rd grade. |
| | Prosonno Kumar Pal ... | 1872 | Sub-Engineer, Orissa Circle. |
| | Troylukho Nath Banerji ... | 1872 | Supervisor, District Board, Muzaffarpur. |
| 25 | F. M. D'Rozario ... | 1872 | District Engineer, Pabna. |
| | Herambo Nath Das ... | 1874 | District Engineer, Mymensingh. |
| | Bhut Nath Chuckerbutty ... | 1874 | Port Commissioners' Engineer, Calcutta. |
| | Prco Nath Ghose ... | 1875 | District Engineer, Tippera. |
| | Kenaram Bose ... | 1875 | Supervisior, Sone Circle. |
| 30 | Mati Lal Ash ... | 1875 | Calcutta Municipality. |
| | Raj Krishna Das ... | 1875 | ..... |
| | Giris Chandra Bhor ... | 1875 | ..... |
| | Benay Krishna Bose ... | 1875 | District Engineer, 24-Parganas. |
| | Durga Charan Chukerbutty ... | 1876 | Supervisor, Sone Circle. |
| 35 | Gopal Lal Banerji ... | 1876 | District Engineer, Darjeeling. |
| | Kissori Mohan Mookerji ... | 1876 | District Engineer, Balasore. |
| | Giris Chundra Datt ... | 1876 | .. ... |
| | Brindaban Chandra Pal ... | 1876 | ..... |
| | Benod Behary Pal ... | 1877 | District Engineer, Noakhali. |
| 40 | Hari Charan Pal ... | 1877 | ..... |

| | L.C.E.—*concluded.* | Year. | Present or last appointment. |
|---|---|---|---|
| | Jogendro Nath Ghose ... | 1877 | District Engineer, Backergunge. |
| | Prasanna Kumar Sen ... | 1877 | ..... |
| | Benoy Krishna Mookerji ... | 1877 | ..... |
| | Purno Chandra Chatterji ... | 1877 | Sub-Engineer, Public Works Department. |
| 45 | Kunjo Bchary Bose ... | 1877 | ..... |
| | Hari Das Chatterji ... | 1878 | ..... |
| | Nebaran Chandra De ... | 1878 | ..... |
| | Priya Krishna Biswas ... | 1878 | Overseer, Public Works Department, 1st Calcutta Division. |
| | Atul Chandra Bandyopadhyay | 1880 | Overseer, 1st grade, Public Works Department, Chota Nagpur, Bengal. |
| 50 | Nogendro Nath Bandyopadhyay | 1880 | Overseer, 1st grade, Public Works Department, Assam. |
| | Bhabadeb Chattopadhyay ... | 1880 | Contractor, Madras. |
| | Ashutosh Chattopadhyay ... | 1880 | District Engineer, Singhbhum. |
| | Gopal Chandra Chattopadhyay | 1880 | Supervisor, Public Works Department, Chota Nagpur. |
| | Abhoya Charan Dutt ... | 1880 | Calcutta Municipal Corporation. |
| 55 | Jnanendro Nath De ... | 1880 | Out of employment. |
| | Bama Charun Mukhopadhyay | 1880 | ..... |
| | Abinash Chander Roy ... | 1880 | Supervisor, Public Works Department, Assam. |
| | Radha Raman Guha ... | 1880 | Officiating Teacher, Civil Engineering College, Sibpur. |
| | Satya Charan Bandyopadhyay | 1881 | Overseer, 1st grade, Public Works Department, Dacca. |
| 60 | Lalit Mohan Basack ... | 1881 | District Board, Mymensingh. |
| | T. B. Byers ... | 1881 | Ganjam Railway, Howrah Municipality. |
| | P. W. Byers ... | 1881 | Supervisor, District Board, Gaya. |
| | Pran Krishna Sen ... | 1881 | Supervisor, Public Works Department. |
| | Bhushan Chandra Bandyopadhyay. | 1882 | Overseer, 1st grade, Public Works Department, Gondock. |
| 65 | Sita Prasanna Roy ... | 1882 | Overseer, 1st grade, Public Works Department (Examiner, lightning conductors, Bengal). |
| | Hari Prosad Ghosal ... | 1883 | Overseer, 1st grade, District Board, Dacca. |
| | J. A. Martin ... | 1883 | Public Works Department, India Government. |
| | C. P. Warde ... | 1883 | Executive Engineer, Calcutta Workshop, Public Works Department. |
| | Akhil Chandra Marik .. | 1885 | Overseer, 2nd grade, Mahanuddy Division. |
| 70 | Banku Behari Mukhopadhyay | 1885 | Overseer, 1st grade, Public Works Department, Puri Division. |
| | L.E. | | |
| | W. A. E. Hanby ... | 1885 | Assistant Engineer, Public Works Department, Bengal Railways. |
| | Hpo Thine ... | 1886 | Assistant Engineer, Public Works Department, Burma. |
| | H. E. W. Martindell ... | 1888 | Assistant Engineer, Public Works Department, Burma. |
| | Hari Charan Mukhopadhyay ... | 1888 | Teacher, Civil Engineering College. |

| | L.E.—*concluded.* | Year. | Present or last appointment. |
|---|---|---|---|
| 5 | Surendro Nath Barat ... | 1888 | Overseer, 1st grade, Orissa Circle. |
| | V. B. Webber ... | 1888 | Temporary Assistant Engineer, Burmah. |
| | Nabakumar Chakrabarti ... | 1889 | District Engineer, Bogra. |
| | Gyanendro Nath Gangopadhyay | 1889 | Temporarily employed, Santipur Municipality. |
| | Krisnadhone Bandyopadhyay | 1889 | Overseer, 2nd grade, Orissa. |
| 10 | Kalibar Bhattacharyya ... | 1889 | Deceased. |
| | Rajendro Nath Mukhopadhyay | 1889 | 2nd grade Overseer, Krisna Nagore |
| | W. S. Bremner ... | 1889 | Assistant Engineer, 3rd grade. |
| | Sarat Chander Sen ... | 1889 | Assistant Surveyor, Surveyor-General's office. |
| | Trailokya Nath Mazumdar ... | 1890 | Overseer, 2nd grade, Orissa Circle. |
| 15 | Nagendra Nath Mitra ... | 1890 | Temporary Assistant Engineer, Burmah, Public Works Department. |
| | F. F. Bion ... | 1890 | Assistant Engineer, Burmah. |
| | Mahendra Nath Dutt ... | 1890 | Assistant Engineer, Public Work Department, Bengal. |
| | Jadu Nath Das ... | 1890 | Unknown. |
| | Bankim Krishna Ghose ... | 1890 | Overseer, Public Works Department. |
| 20 | Abdul Rahman ... | 1890 | Unknown. |
| | G. J. St. C. Sedgley ... | 1891 | Assistant Engineer, Public Works Department. |
| | Satyaranjan Khastgir ... | 1891 | Overseer, Cuttack, Public Works Department. |
| | Upendra Nath Mukhopadhyay | 1891 | Ditto. |
| | Ahindro Chandra Mukhopadhyay. | 1892 | Practical training. |
| 25 | Anango Mohon Pal ... | 1892 | Ditto. |

*N.B.*—Any inaccuracies in the above list should be brought to the notice of the Principal. Passed students out of employ should register their names and addresses in the Principal's office. It is particularly requested that on any student getting an appointment or changing his appointment, the information be forwarded to the Principal for incorporation in the College Calendar.

# ENGINEER DEPARTMENT.

## SCHOLARS AND MEDALLISTS.

### *Forbes' Memorial Scholars.*

1880 { Bhusan Chandra Bandyopadhyay.
Kali Gopal Rudra.

1881 Not awarded.

1882 { C. P. Warde.
Hari Pada Ghosal.

1883 W. A. E. Hanby.

1884 { Tarak Chandra Ghose.
Hpo Thine.

1885 Not awarded.

1886 { H. E. W. Martindell.
Hari Charan Mukhopadhyay.

1887 { Nogendra Nath Mukhopadhyay.
Rajendra Nath Mukhopadhyay.

1888 { Adhor Lal Chandra.
W. S. Bremner.

1889 { Mohindra Nath Datta.
Haridas Gangopadhyay.

1890 { Giris Chandra Das.
Modhu Sudan Sen Gupta.

1891 { Ahindra Chandra Mukhopadhyay.
Amullya Kristo Bhattacharjee.

1892 { Syama Charan De.
Pyari Charan Gupta.

### *Ambika Charan Chaudhuri Medallists.*

1880 Upendro Nath Bandopadhyay.

1881 } Not awarded.
1882 }

1883 Rajendra Nath Mukhopadhyay.

1884 } Not awarded.
1885 }

1886 Sorabji Shavaksha.

1887 Beni Madhab Mittra.

1888 Nogendro Nath Mukhopadhyay.

1889. Satish Chandra Chattopadhyay.

1890 Khirode Chandra Mukhopadhyay.

1891 Giris Chandra Das.

1892 Madhusudhun Sen Gupta.

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*Trevor Medallists.*

1891 Mohini Mohan Lahiri.

1892 Ahindra Chandra Mukhopadhyay.

# CIVIL ENGINEERING COLLEGE, SIBPUR.

## APPRENTICE DEPARTMENT.

### GENERAL RULES.

1. The College is under the general supervision of a Board of Visitors appointed by the Government.

2. The Principal of the College is charged with the general control of the Institution, including the regulation of the course of study, the supervision of the mess and other domestic arrangements, and the maintenance of discipline; and he will from time to time issue such rules as may be necessary to secure those objects. The workshops are under the control of the Executive Engineer, and the apprentices while at work in them will be under his orders; but all breaches of discipline will be reported by him to the Principal.

### RULES FOR ADMISSION.

3. For admission to the Apprentice Department a candidate must be at least 15 and not more than 17 years of age.

4. Every candidate must apply in writing for permission to appear at the examination, and all applications must reach the Principal on or before the 15th December. Each application must be accompanied by a fee of Rs. 2, a certificate of good conduct, and a certificate of age. Applications unaccompanied by fee and proper certificates will not be considered, and after this date all undecided cases will be rejected. The subjects of examination are—

| | |
|---|---|
| Arithmetic (the whole). | Euclid (Books I and II). |
| Algebra to simple equations, inclusive. | English (grammar and composition). |

Candidates who have passed by Standard VII of the Code for European Schools, or the University Examination in English and Mathematics, are admitted without further test and without payment of a fee. They must submit their applications accompanied by a certificate of age and a certificate showing that they have passed the requisite standard, so as to reach the Principal not later than the 15th January of each year. No applications will be attended to after this date.

5. Every applicant, before admission to the College, will be examined by the College Surgeon as to his physical strength, chest measurement, fitness for manual labour, and eyesight. If this officer's report is unsatisfactory, the applicant will not be admitted: his fee, however, will be returned.

6. Before an apprentice is admitted to the College, his parent or guardian must sign an agreement in the form shown in Appendix A.

7. The session begins on the first Monday in February. All apprentices are required to join the College on that date. Any apprentice prevented by sickness from attending on the opening day must produce a certificate to that effect from a Civil or Assistant Surgeon, failing which he will be liable to a fine not exceeding Rs. 10. No apprentice will be admitted or re-admitted to the College after the close of the month of February, except by special order of the Director of Public Instruction. This permission will only be given under exceptional circumstances.

### Course of Instruction.

8. There will be a long vacation from about the middle of August to the end of October. Every apprentice must leave the College during this vacation, and parents or guardians must satisfy the Principal, before their sons or wards can be admitted, that they are able to conform to this rule.

9. The full course of instruction in this class will extend over five years, during the first three and a half of which the instruction will be both theoretical and practical. The last year and a half will be spent entirely in practical work. For details of the course of study, *see* Appendix B.

10. Every apprentice who passes the annual examination held at the end of the second year will be entitled, on leaving the College, to a certificate, stating that the holder possesses the theoretical qualifications required of a sub-overseer in the Public Works Department.

11. An apprentice who passes the final examination held at the end of three years and a half will be entitled to a third grade overseer's certificate.

12. On the completion of his practical course, an apprentice will be entitled to a first or second grade overseer's certificate, according to the estimate formed of his work by the College authorities. A College certificate gives the holder no claim to a Government appointment.

13. No apprentice who at the end of three years and a half leaves the College with a third grade overseer's certificate will at any future time be allowed to return for his practical course.

14. Every apprentice who leaves the College after the expiration of the five years' course will receive a certificate in the form shown in Appendix C, provided that he has attended the workshops on 80 per cent. of working days during the last 18 months of his apprenticeship.

[Note :—

*Extract from the* "Calcutta Gazette" *of the 16th March 1887, page 79, Part IB.*

A candidate for employment on the Subordinate Engineering Staff of the District Engineer must be qualified in one of the manners following, that is to say :—

(1) If the pay of the appointment is Rs. 60 per mensem, or more, he must hold—

(*a*) a certificate from the Principal of the Government Engineering College at Sibpur that he has served his apprenticeship there and passed the final examination qualifying him for employment in the Public Works Department as a Foreman Mechanic or an Upper Subordinate.]

15. Apprentices will attend in the class-rooms and in the workshops in accordance with the College time-table. The hours of work may vary with the seasons of the year.

16. All apprentices will be required to reside on the College premises, so far as the accommodation will permit.

### Free and reduced fee list.

17.* European or Eurasian apprentices, up to the number of twenty-five, are received into this Department on payment of Rs. 5 a month for the twelve months of the year. The cost of messing is estimated at Rs. 20 a month. In the case of these twenty-five apprentices, the balance, viz. Rs. 15 a month, will be paid to the mess fund by

* These rules apply only to apprentices whose parents or guardians reside within the limits of the jurisdiction of the Lieutenant-Governor of Bengal; but the sons of East Indian Railway employés, of soldiers serving in India, and of Survey, Telegraph, and other Government officers who are liable to be employed in Bengal, are admissible to the reduced fee list.

As reduced feeships, &c., are awarded by the Board of Visitors after the opening of the section to those apprentices who may have joined the College, none can be guaranteed beforehand. Forms to be filled up for the consideration of the Board are supplied on application.

Government. In addition five such apprentices are admitted free. Thus the total of free apprentices and apprentices on a reduced fee will be thirty.

18. Europeans and Eurasians in excess of that number will be received as apprentices into the College, so far as the accommodation will permit, on paying the full cost of their messing, viz. Rs. 20 a month. This charge will be payable during the term, reckoned at nine months and a half. During the vacation, taken at two months and a half, a charge of Rs. 2 a month will be made to defray the cost of maintaining mess servants.

19* Native apprentices up to the number of forty will be received into the apprentice department on payment of Rs. 2 a month for the twelve months of the year. The cost of messing is estimated at Rs. 7 a month. In the case of these forty apprentices, the balance, viz. Rs. 5 a month, will be paid to the mess fund by Government.

20. Native apprentices in excess of this number will be received into the College on paying the full cost of their mess, viz. Rs. 7 a month. This charge will be payable during the term, reckoned at nine months and a half. During the vacation, reckoned at two months and a half, a charge of Re. 1 a month will be made to defray the cost of superintendence and mess servants.

### Stipends.

21. After the final examination, 10 stipends of Rs. 10, and 10 of Rs. 6 each, tenable for one year and a half, will be awarded to those apprentices who pass the best examination, both theoretical and practical.

### Standing orders for students.

22. Every resident European apprentice will join the European mess. On joining the mess every apprentice will pay an entrance fee of Rs. 10 to the mess fund to provide for the cost of crockery, knives and forks, table linen, &c. A list of breakages and other damage done will be prepared monthly, and each apprentice will be required to pay, by the 15th of the following month, an equal share of the cost. On leaving the mess, if an apprentice has paid all demands, his entrance fee will be returned to him; otherwise it will be forfeited to the mess fund.

23. Hindu apprentices must ordinarily join the College mess for Hindus, and abide by the rules sanctioned by the Principal for the management of their mess. Each student on joining the mess will be required to deposit "caution money" to the amount of Rs. 5, which will be ultimately returned to the student if he has not rendered himself liable to the forfeiture of the whole or any part of it.

24. Each resident apprentice must provide his own clothing, and bedding, and a bedstead. No furniture may be brought into the College without special permission.

25. All payments must be made into the Principal's office on or before the 15th of the month for which the money is due, after which date no payment will be taken unless accompanied by a fine of Re. 1

* These rules apply only to apprentices whose parents or guardians reside within the limit of the jurisdiction of the Lieutenant-Governor of Bengal; but the sons of East Indian Railway employés, of soldiers serving in India, and of Survey, Telegraph, and other Government officers who are liable to be employed in Bengal, are admissible to the reduced fee list.

As reduced feeships, &c., are awarded by the Board of Visitors after the opening of the session to those apprentices who may have joined the College, none can be guaranteed beforehand. Forms to be filled up for the consideration of the Board are supplied on application.

for every three days of delay. If the payment is not made during the month for which it is due, the defaulting apprentice's name will be struck off the College books and he will not be re-admitted until he has paid all arrears with fines.

26. The monthly charge for messing may, if necessary, be altered from time to time in reference to the prices of provisions.

27. All breaches of discipline committed by any apprentice will be reported to the Principal, who will dispose of them according to the rules and practice of the Education Department.

28. A conduct register of each apprentice will be kept by the Principal. The Principal has no power to cancel or alter an entry once made and signed.

29. Apprentices are liable to have their names placed in the conduct register as defaulters for the following offences:—

(i) Disobedience of orders.
(ii) Absence without leave.
(iii) Idleness.
(iv) Insubordination or disrespect to the College or workshop authorities.

30. Apprentices may be removed from the College for habitual or gross misconduct, for continued idleness, or neglect of work, or for frequent entry in the conduct register. Every such removal should be reported to the Director of Public Instruction, and any fees paid by the apprentice shall be forfeited.

31. Every apprentice will be responsible for any machines, tools, or other articles that may be placed in his charge. He must produce them when called upon to do so, and must at once report any damage done to them. In case of loss or damage arising from carelessness, he may be called upon to pay the cost.

32. A certain number of the apprentices will be appointed monitors, whose duty it will be to assist the College authorities in the maintenance of discipline. For the performance of this duty each monitor will receive a small sum monthly.

33. Any monitor may be removed by the Principal for misconduct or for inefficiency in the discharge of his duties.

34. No resident apprentice will ordinarily be allowed to keep a private servant.

35. On Sundays all resident Christian apprentices, Protestant and Roman Catholic, will be required to attend the services held in their respective chapels.

36. All apprentices will be required, while in the workshops, to wear a uniform dress, which will be supplied to them at cost price.

37. Leave will be granted by the Principal only. No leave will be granted except on a written application.

38. No resident apprentice may leave the College premises without the written orders of the Principal, whether on special leave or on a general holiday.

39. All European apprentices will be encouraged to join the Volunteer Corps. Those who join it will be allowed such occasional leave as may be required by the regulations relating to Volunteers.

40. All apprentices are obliged to join the College Athletic Club, the subscription to which is Re. 1-8 per annum, and the entrance fee one rupee.

# APPRENTICE DEPARTMENT.

## *List of Books to be procured by Apprentices.*

Students will provide themselves with the following books:—

| | | | |
|---|---|---|---|
| First year | Arithmetic | ... | Charles Pendlebury's. |
| | Euclid | ... | Hall and Steven's. |
| | Algebra | ... | Hall and Knight's Elementary Algebra. |
| | Mensuration | ... | Todhunter's. |
| | Engineering | ... | Elementary "Building, Construction, and Drawing," by Edward J. Burrel. |
| | Drawing | ... | Linear Drawing (Davidson's). |
| Second year | Trigonometry | ... | Hamblin Smith's. |
| | Chemistry | ... | Remsen's Elements of Chemistry. |
| | Surveying | ... | Roorkee papers. |
| | Estimating | ... | Roorkee examples. |
| | Drawing | ... | Projection (Davidson's). |
| Third year | Statics | ... | Blaikie's Dynamics. |
| | Hydrostatics | ... | |
| | Physics | ... | Balfour Stewart's Lessons in Elementary Physics. |
| Fourth year | Dynamics | ... | Blaikie's Dynamics. |
| | Steam-Engine | ... | Holme's. |
| | Mechanism | ... | Tate's. |

# APPENDIX A.

## CIVIL ENGINEERING COLLEGE, SIBPUR.

*Memorandum of the conditions under which* _____
*is admitted as a Mechanical Apprentice to the Civil Engineering College, Sibpur.*

1. He will be subject to the regulations set forth in the "Rules of the Mechanical Apprentice Class."
2. He will pay his own travelling expenses to Sibpur.
3. He will be on probation for six months: at the end of which time, if it appears that he is not physically fit for the work, or if for any reason (other than misconduct) it appears inexpedient to retain him, he will be sent back to his friends at the expense of Government.

4. The undersigned _____
will for five years, beginning from the date of admission to the College,

provide _____
with suitable clothes and the books required in his class; and will pay in advance to the Principal of the College, on or before the 15th of each month, the sums stated in Rules 17, 18, 19, 20, 22, 23, and 24. He will also make arrange-

ments for the removal of _____
from the College during the long vacation, under Rule 8, or any other time when required by the Principal.

5. In consideration of the foregoing conditions, _____

_____
will be fed and lodged for a period of five years (excluding vacations), and will receive such instructions as will qualify him for employment as an Upper Subordinate in the Public Works Department and as a Foreman Mechanic.

6. Employment is not guaranteed after completion of apprenticeship.

Signature of parent or guardian. _____

Address. _____

Signature of witness. _____

Address. _____

Signature of the Principal, Civil Engineering College, Sibpur.

_____

*Dated the* *day of* 18

# APPENDIX B.

*Course of Study for the Apprentice Department.*

| | First year, Feb. to Aug. | Second year, Nov. to Aug. | Third year, Nov. to Aug. | Fourth year, Nov. to Aug. |
|---|---|---|---|---|
| Mathematics ... | Arithmetic, the whole. Euclid Books III, IV, VI, and definitions of V. Todhunter's Algebra to end of Chapter 32, omitting scales of notation. Mensuration. | Algebra to end of Binomial Theorem. Trigonometry. Mensuration. | Statics, Besant's Hydrostatics, Chapters I to IV, inclusive. | Todhunter's Mechanics for Beginners, articles 1 to 50, Chapters VII, VIII, IX, XVII, and article 152. Hydrostatics, Chapters V to VII, inclusive. |
| Engineering ... | Carpentry ... ... | Estimating; Building materials. | Masonry; Estimating, Roads. | Applied Mechanics, Mechanism and the steam-engine, Buildings, Bridges. |
| Natural Science | ..... | Chemistry ... ... | Heat ... ... | Electricity and Magnetism. |
| Surveying ... | ..... | Surveying with chain and prismatic compass, and Levelling. | Plane Table, Box-sextant, Theodolite and Levelling. | Laying out curves, and Field work generally. |
| Drawing ... | Printing Scales, Geometrical drawing. | Orthographic projection ... | Engineering and Machine drawing. | Sketching and Machine drawing. |

# APPENDIX C.

*Leaving Report of* , *an Apprentice in the Engineering College, Sibpur.*

| | | | | |
|---|---|---|---|---|
| Entered | 18 | Age on entering | years | months. |
| Apprenticeship expired | 18 | Age on leaving | ,, | ,, |
| Left | 18 | | | |

Apprentice appeared at the final examination held on the , and obtained marks as follows :—

| Subject. | Full marks. | Marks obtained. | Remarks. |
|---|---|---|---|
| Mathematics ... ... ... ... | | | |
| Natural Science ... ... ... ... | | | |
| Surveying ... ... ... ... | | | |
| Drawing ... ... ... ... | | | |
| Engineering ... ... ... ... | | | |
| Ditto (practical course) ... ... | | | |
| Total ... | | | |

Apprentice has spent time in the shops as follows :—

| | Time spent in each. | Proficiency. |
|---|---|---|
| Carpenters' shop ... ... ... | Months. | |
| Blacksmiths' ,, ... ... ... | ,, | |
| Moulders' ,, ... ... ... | ,, | |
| Fitters' ,, ... ... ... | ,, | |
| Founders' ,, ... ... ... | ,, | |

Apprentice held the post of Monitor for months.

Apprentice's character is as follows as regards the qualities mentioned :—

I.—Truthfulness.

II.—Industry.

III.—Energy.

IV.—Obedience.

General Remarks.

*Conclusion.*—On the whole we consider that this apprentice is qualified for employment in the Public Works Department as a

*Executive Engineer,*
*Calcutta Workshops Divn.*
Sibpur,

*Principal, Civil Engineering College,*
*Sibpur.*

*The* 18

# APPRENTICE DEPARTMENT.

## WORKSHOP COURSE.

Workshop Hours, Junior Apprentices 8—11. Senior Apprentices 8—11 and 12-30—4.

### First year.

*Carpenters' shop.*—Apprentices are made acquainted with and shown how to use and handle properly the tools ordinarily employed for the purposes of carpenters' and joiners' work. They are taught the methods of preparing wood, setting out, and forming the various joints. The practical application of the foregoing instruction is brought to bear by employing them in making tools, boxes, doors, windows, roof trusses and other framings required for buildings and other engineering works.

### Second year.

*Blacksmiths' and Boiler-makers' shop.*—Apprentices are taught to use and handle correctly the different tools, to lay and manage the fires, to draw down, bend, jump, weld, split, punch, chamfer, and temper. After this they are set to make small forgings of tools, bolts, nuts, hooks, and shackles, and also of parts of trusses, as well as other forgings of parts of machines. In the boiler-makers' shop they are familiarised with the use of riveting tools and the process of riveting, and learn to punch and shear correctly with the machines for that purpose.

### Third year.

*Vicemen and Fitters' shop.*—The apprentices are put through a course of chipping, filing, and fitting so as to gain experience in the tools used by this class of workmen, after which they make up various tools required in the fitters' shop and assist in ordinary fitting work. Those who prove themselves sufficiently proficient are then put on as attendants to the workmen employed on the different machines so as to acquire a knowledge of lathe-work, such as facing, surfacing, turning, boring, and screw cutting, and also shaping, drilling, slotting, and planing in the machines used for these purposes. They thus gain confidence in using these machines so as to be entrusted to work them by themselves.

## EXAMINATIONS.

Annual examinations are held at the end of the first, second, and third years. Each apprentice has to produce within a given time certain tasks allotted him bearing upon the instruction received during the course of the year. These examinations are held personally by the Executive Engineer.

### Fourth year.

*Foundry or moulding shop.*—Only six months of the apprentices' time is devoted to this shop. They learn to use the various moulders' tools, to mix foundry sand and loam, to make small moulds from patterns supplied, and are shown how to ensure good work and clean castings. They are also taught how to prepare and charge the cupolas. An insight into the nature of the wooden patterns required for forming the moulds being thus obtained, they are set to work with the pattern-makers to make small patterns, from which they are expected to produce castings.

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## EXAMINATIONS.

At the end of the three and a half years the apprentices having gone through the various shops have a final examination, and at a given time have to produce pieces of work requiring the use of the different tools used in the respective shops, to show that the skill acquired by them has been maintained, and that they show sufficient mechanical aptitude to be considered fit to complete their apprenticeship. During the three and a half years theoretical instruction in the College and practical training in the workshops are simultaneously carried on, but during the remaining one and a half years they are solely employed in the shops, and are designated "senior apprentices."

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### Fourth and Fifth years.

*Senior Apprentices*—Are employed independently on the lathes, drills, shaping, slotting, planing, punching, shearing, and screwing machines, and are taught to set out and mark off work for them, these machines being brought into use to make tools, machines, parts of engine and pump fittings, and any other instructive work that may be going on in the shops. They assist generally in the repairs to the hulls and machinery of dredgers and launches, also in repairs to portable engines, centrifugal, donkey, and other pumps. They are taught to make steam joints, pack glands, set valves, and get up steam and drive engines so as to be competent to take charge of (as well as carry out any necessary repairs to) portable or fixed engines and boilers or a steam-launch. They are also instructed in laying out work to full size on the drawing boards, from drawings, for the use of the workmen.

# APPRENTICE DEPARTMENT.

## ADMISSION EXAMINATION, 1892.

### ARITHMETIC AND ALGEBRA.

1. Simplify :—

(1) $\dfrac{\frac{2}{7} + \frac{2\frac{2}{3}}{3\frac{1}{5}} + \frac{2\frac{1}{7}}{7\frac{1}{2}}}{5\frac{8}{15} - 4\frac{1}{5}} + 4\frac{3}{11} \times 2\frac{3}{4} + 1\frac{1}{2}$.

(2) $\dfrac{\cdot 12 \text{ of } (\cdot 0104 - \cdot 002) + \cdot 36 \times \cdot 002}{\cdot 018 \times \cdot 8}$.

2. Find (1) the G.C.M. and L.C.M. of 8400, 3780, 8232, and (2) the square root of 108083·1376.

3. Water flows into a rectangular cistern through a pipe of 12 square inches aperture, at the rate of 2 feet 4 inches per second, and flows out through an orifice 7 square inches at 2 feet 1 inch per second. In what time will three-fourths of the cistern be filled, its dimensions being 15 feet 5 inches long, 13 feet 5 inches wide, and 6 feet 8 inches deep?

4. Find by Practice the value of 15 tons 9 cwt. 36 lbs. @ £1·15*s.* 6*d.* per ton.

5. What income will be derived from investing Rs. 10,386 13 as. in 5 °/₀ municipal debentures at Rs. 110, deducting income-tax at 5 pies in the rupee?

6. Simplify (1) $\frac{1}{6}\left\{x(x+1)(x+2) + x(x-1)(x-2)\right\} + \frac{2}{3}(x-1)x(x+1)$.

Divide (2) $x^4 - \dfrac{1}{x^4}$ by $x - \dfrac{1}{x}$.

7. (1) Find the L.C.M. of $x^2 + x - 12$, $x^3 + 5x^2 - 26x - 120$, $x^3 - 27x + 54$.

(2) Reduce $\dfrac{(a+b)\left\{(a+b)^2 - c^2\right\}}{4b^2c^2 - (a^2 - b^2 - c^2)^2}$ to its lowest terms.

8. Solve the equations :—

(1) $\frac{6x-4}{21} + \frac{x-2}{5x-6} = \frac{2x}{7}$,

(2) $\frac{13-2\sqrt{x-5}}{13+2\sqrt{x-5}} = \frac{3}{23}$.

(3) $\frac{a}{x} + \frac{b}{y} = m$ and $\frac{b}{x} + \frac{a}{y} = n$.

9. An estate consists of two parts, one of which is twice as valuable as the other. A person who has a 4-anna share in the more valuable part sells $\frac{1}{3}$ of his share. With the proceeds of the sale and Rs. 6,000 he buys an 8-anna share in the other part. What is the value of the estate?

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## GEOMETRY.

*Time*—2 *hours.*

1. (*a*) Define—Adjacent angles; Alternate angles; Problem; Postulate; Segment of a straight line.

(*b*) Distinguish between "Converse" and "Contrary" propositions.

2. Enunciate all the propositions in Book I which have been proved on the identical equality of triangles.

3. Prove the last one of them in the above question.

4. In a right-angled triangle the square described on the hypotenuse is equal to the sum of the squares described on the other two sides.

5. To divide a given straight line so that the square on one part may be double of the square on the other.

6. Equal triangles, on equal bases in the same straight line and on the same side of it, are between the same parallels.

7. Prove that the rectangle under the sum and the difference of two straight lines is equal to the difference of the squares on the lines.

8.—To describe a square that shall be equal to a given rectilineal figure.

*N.B.*—Five marks for neatness of handwriting.

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## ENGLISH.

1. Define an *Adverb*, a *Preposition*, a *Conjunction*, and give the derivation of the words. Form a sentence containing each of the above and underline them.

2. Write down (*a*) the diminutive of *duck, stream, hill, animal, dear*, (*b*) the plural of *leaf, goose, son-in-law, radius, church, madam*, (*c*) the feminine of *beau, stag, hero, poet, emperor, actor*, (*d*) the perfect and past participles of *sing, forget, drive, shake, swim, steal, tread, win, weave, swell.*

3. Write down the comparative and superlative of—*good, truthful, ill, bitter, gay, modest, useful, patient, frugal, red, rough, late, bad, far, nigh.*

4. Parse fully the underlined words in the following sentences:—

(*a*) *The more*, the merrier.
(*b*) *Half* a loaf is better than no bread.
(*c*) A new work is *preparing* for the press.
(*d*) He went *away* in a rage.
(*e*) This is far and *away* the best.

5. Correct the following, giving the true idiom :—

(*a*) He ought to turn over a new page.
(*b*) We ought always to provide amends for wrong-doing.
(*c*) I am afraid I shall not reach the train; it starts at 8-30 o'clock.
(*d*) Wrong or right, I am determined to go.
(*e*) His friends, washed in tears, stood round his bed.
(*f*) I cannot sit on the bench; there is no place.
(*g*) The history is a hardest subject to learn well.

6. Form sentences illustrating the difference of meaning between (1) *affected* and *affecting*; (2) *corporal* and *corporeal*; (3) *stationary* and *stationery*; (4) *verity* and *veracity*.

7. Write a letter to a friend describing the premises, studies, and games of your school or college *or* a letter to the head of a department asking for a situation.

8. Write a short essay on the influence of good example.

# APPRENTICE DEPARTMENT.

## MONTHLY EXAMINATION.

### MARCH 1892.

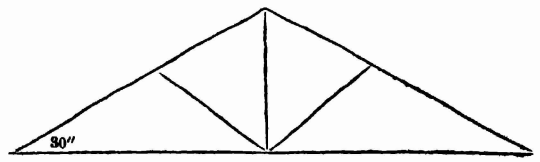
*4th year.*

1. Distinguish between "retaining wall" and "breast wall." Explain what is meant by the "angle of repose," "coefficient of friction," "line of rupture," and "centre of pressure."

2. Show how you would find the pressure which a mass of earth exerts against the back of a retaining wall with vertical sides, the earth being on a level with the top of the wall.

3. Find the thickness of a retaining wall necessary to resist the pressure of water on one face of it, the surface of the water being on a level with the top of the wall which is 12 feet high. Weight of a cubic foot of masonry = 112 lbs.

4. Each rafter of a king-post truss, of which the marginal figure is a sketch, supports a portion of roof 12 feet × 5 feet, and the weight of roof covering is 100 lbs. per square foot: find the strains on the several pieces of the truss by means of diagrams drawn to any convenient scale, say 1,000 lbs. = 1″.




5. Name the principal elements of a steam-engine and describe the arrangement adopted in practice.

6. Sketch and explain the construction of a steam-engine cylinder with all its fittings complete.

7. Mention some of the most obvious advantages and uses of machinery and the means by which the forces applied to machinery are developed.

8. Prove the principles of virtual velocities in the case of three systems of levers and give an example of each.

9 Define *Boreal Pole*, *Magnetic meridian*, *declination*, *inclination*, *armatures*.

State the laws of electrical attraction and repulsion.

10. What is a lightning conductor? In what way does it act? Suppose you were required to extemporise one for a detached house, give an account of the manner in which you would proceed.

11. A man swims across a river with velocity 3·6; the velocity of the current is 10·5. Find the resultant velocity of the man.

12. A body has initial velocity $ng$ and uniform acceleration $g$ opposite to the direction of motion; show—

(1) That its velocity after $n + r$ secs. is equal and opposite to its velocity after $n - r$ secs.
(2) That its distances from its starting point at the above-mentioned times are equal.

---

*3rd year.*

1. The side AB of a triangle ABC is 2,345 feet, and the angles CAB and ABC are 63° 24′ 36″ and 56° 35′ 24″ respectively. Calculate the lengths of AC and BC.

2. In any triangle, prove that $\text{Sin } \frac{A}{2} = \sqrt{\frac{(s-b)(s-c)}{bc}}$, where $s = \frac{a+b+c}{2}$.

3. If A + B + C = 180°, prove that Sin 2A + sin 2B − sin 2C = 4 sin C. cos A. cos B.

4. Explain how a force is geometrically represented. Explain the principle of transmissibility of force.

5. Assuming the truth of the parallelogram of forces for the direction of the resultant, prove it for the magnitude.

6. Enunciate and prove the principle called the "triangle of forces."

7. (*a*) Give sketches of the junction of the rafter with the end of the tie beam. (*b*) Show how would you scarf a beam subjected to transverse strain. Give reasons for your answer.

8. Explain the method of lowering "centres" by means of sand cylinders.

9. Describe Rutherford's maximum and minimum thermometers.

10. State the causes which affect the boiling point of a liquid. Define latent heat and show how to find the latent heat of ice.

11. What takes place when an acid and a base are brought together? What is formed? How can you conveniently determine whether a substance is an acid or a base?

Give the names and formulæ of the potassium salts of hypochlorous acid, perchloric acid, chloric acid, nitric acid.

12. What subjects would a thorough study of each metal include? Describe the preparation of caustic potash.

*2nd year.*

1. When mercuric oxide is heated in a dry tube, describe what happens. Pour dilute sulphuric acid on zinc; describe what happens and what is left. (No equations are to be given.)

2. Mention the three kinds of chemical action; what kind of chemical action took place respectively in the experiments referred to in Question 1?

3. What happens when a small piece of zinc is heated in air? How can you show that air causes the change? Of what substances does air consist? In what proportion? Are they mixed chemically or mechanically? Give reasons for your answer.

4. How can you distinguish between the following gases:—

O, H, $NH_3$, $N_2O$, NO?

Describe the preparation of NO, giving equations.

5. Explain the following terms:—Angle of repose, spoil-bank, borrow-pits, side-widths, shoulders, cheeks and root of a tenon.

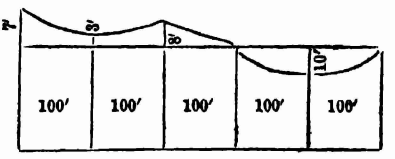
6. Sketch and explain the different methods of joining two pieces of wood together.

7. Describe briefly the successive operations of laying out a piece of earthwork on the ground.

8. Estimate the quantities of earthwork in embankment and cutting from the following data:—

Formation width = 30.
Side slope = 2 : 1.
The ground is level across.

Longitudinal section.




9. (*a*) Show that the angle subtended at the centre of a circle by an arc equal to the radius is the same for all circles.

(*b*) Find the trigonometrical ratios for an angle of 30°.

10. Show that—

(*a*) $(\sec\theta - \operatorname{cosec}\theta)(1 + \cot\theta + \tan\theta) = \frac{\sec^2\theta}{\operatorname{cosec}\theta} - \frac{\operatorname{cosec}^2\theta}{\sec\theta}$.

(*b*) $(\cos^2\theta - 1)(\cot^2\theta + 1) = -1$.

(*c*) $(\operatorname{cosec}\theta - \cot\theta)^2 = \frac{1 - \cos\theta}{1 + \cos\theta}$.

11. (*a*) Show that $(a-b)^3 + (b-c)^3 + (c-a)^3 = 3(a-b)(b-c)(c-a)$.

(*b*) If $2s = a + b + c$, prove that $(s-a)^2 + (s-b)^2 + (s-c)^2 + s^2 = a^2 + b^2 + c^2$.

(*c*) Resolve $4(ad + bc)^2 - (a^2 - b^2 - c^2 + d^2)^2$ into four factors.

12. Similar triangles are to one another in the duplicate ratio of their homologous sides.

---

*1st year.*

1. What is the general principle of a good joint. Distinguish between a scarf and a fish joint; give examples with sketches.

2. Sketch clearly the various joints used in a king-post truss.

3. What is the working size of burgahs used in roofs? Give sketches of a joint used in a beam to carry a roof.

4. Solve the following equations:—

$(a)$ $x^2 - xy = 35xy - y^2 = 18$; $(b)$ $x^2 + (a + b)\,x + ab = o$.

5. Extract the square roots of $9x^4 + b^2\,x^2 - 3ax^3 - abx^2 + 6bx^3 + \frac{a^2\,x^2}{4}$, and $4\,x^2\,(x^2 - y) + y^2\,(4\,x^2 + 1) + y^3\,(y - 2)$.

6. For a journey of 108 miles 6 hours less would have sufficed had one gone 3 miles an hour faster. How many miles an hour did one go?

7. The radius of a circle is divided into four equal parts, and at the 3 points of division straight lines are drawn at right angles to the radius to meet the circumference. Find the lengths of these straight lines in inches to two places of decimals, that of the radius being one foot.

8. The parallel sides of a trapezoid are respectively 8 feet and 14 feet; two parallel straight lines are drawn across the figure parallel to them, so that the four are equidistant, find the lengths of the straight lines.

9. Calculate to four places of decimals the length of the side of a regular polygon of twelve sides inscribed in a circle of 1 foot radius.

10. Enunciate and prove the VIIth proposition of Book II.

11. The straight line which joins the middle point of the hypotenuse of a right angled triangle to the right angle is always equal to half the hypotenuse.

12. Construct a triangle, having given the base, the sum of the sides, and one angle at the base.

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APRIL.

*4th Year.*

1. $(a)$ Explain what is meant by the "bending moment" and "shearing force" in a beam or girder; and also by the "effective depth" of a girder.

$(b)$ Why are the flanges of a large built girder made of several pieces of plate iron in the middle decreasing to one or two towards the sides?

2. Show how you will find the bending moment in the middle of a girder uniformly loaded, and also at any point distant $x$ from the support, and hence find the strain on the flanges at these points.

3. Find the shearing force at any point in a uniformly loaded girder, and also the maximum shear caused by a heavy moving load such as that of a railway train.

4. Find the number of beams 6″ × 8″ required for the roof of a room 30 feet long by 12 feet broad, the weight of roof covering being 100lbs. per superficial foot. The breaking weight in the middle of a piece of similar wood 1 inch square in section and 1 foot long = 562½lbs. Factor of safety = 10.

5. Define *voltaic couple*, *electromotive series*; what is the positive pole in cells composed of the following couples? zinc—iron; gold—lead; copper—graphite. Describe Bunsen's Battery.

6. What is electrolysis? In water electrolysis what is the most probable explanation of the phenomenon? Describe what happens in the electrolysis of copper sulphate.

7. Show how to compare the specific gravities of a solid and a fluid by Nicholson's hydrometer.

8. Equal weights of two fluids of which the specific gravities are $s$ and $2s$ are mixed together, and the mixture occupies three-fourths of the sum of the volumes of its components. Find the specific gravity of the mixture.

9. Compare the action of a crank with that of an eccentric, and sketch and explain the construction of an eccentric.

10. Mention the two ways in which the governor of a steam-engine acts upon the steam supply. Explain the action of the most common form of governor invented by Watt.

11. What are the rules to be observed in transferring motion from one axle to another by means of belt-gearing, and show by a sketch how guide-pulleys may be employed to transfer motion from one wheel to another, whose axes have any given direction.

12. What do you mean by the terms pitch circles, pitch of the teeth, root and flank of a tooth. What would be the proportions of the radii of the pitch circles, and what would be the forms of the teeth, so that the wheels may have perfect rolling contact between them.

### *3rd Year.*

1. Describe Newcomen's Steam-Engine and Watt's improvements.

2. Define "Mechanical equivalent of Heat," and describe Joule's apparatus for its determination.

3. Of what minerals are the following substances compounds? soapstone, meerschaum, asbestos, epsom salt, white vitriol, blue vitriol, cinnabar, calomel, corrosive sublimate, galena, lunar caustic? Give the formulas of all, except the first three.

4. Give the formulæ of potash alum, soda alum and ammonium alum. Describe the properties and uses of potash alum.

5. Find from the Tables, L cos 88° 45′ 16″.

6. While sailing south-west two ships are seen at anchor, one N.N.W. and the other W.N.W. After sailing five miles these ships are seen N. and N.W. respectively. Determine their distance from each other.

7. In a triangle, given $a = 10$, $b = 15$, L sin $A$ = 9·5228787 log 3 = ·4771213 : find $B$.

8. Find the magnitude and direction of the resultant of two unlike parallel forces acting on a rigid body.

9. If two forces acting at the extremities of a lever produce equilibrium, they are to one another inversely as the perpendiculars drawn from the fulcrum on their lines of action.

10. Find the centre of gravity of a triangle.

11. What is the chief point to be taken into consideration in the construction of a wooden partition when there is no wall underneath it. Give sketch of a wooden partition for a room 20 feet broad.

12. Give sketch of a queen-post truss with the names of the several pieces of timber used in it.

---

*2nd Year.*

1. Sketch a king-post truss, naming all its parts and showing the joints of the king-post, with rafters and tie-beam, in detail.

2. Sketch and explain the consrtuction of a single-joisted wooden floor.

3. What are the most efficient means of protecting iron fastenings of timber?

4. How can a beam of large scantling be built of long pieces of small scantling, and how are trussed beams made. Illustrate your answer by a sketch of each sort.

5. Prove that sin (90° — A) = cos A, cos (90° + A) = — sin A. and cos (180° — A) = — cos A.

6. Find a value of $\theta$ which will satisfy the following equations:—

(*a*) sec $\theta$ cosec $\theta$ + 2 cot $\theta$ = 4. (*b*) sin $\theta$ + cos $\theta$ = $\sqrt{2}$

(*c*) sin $\theta$ + cos $\theta$ = $2\sqrt{2}$ sin $\theta$ cos $\theta$.

7. Prove that:—

(*a*) $\left(\frac{b}{c} + \frac{c}{b}\right)^2 + \left(\frac{c}{a} + \frac{a}{c}\right)^2 + \left(\frac{a}{b} + \frac{b}{a}\right)^2 = 4 + \left(\frac{b}{c} + \frac{c}{a}\right)\left(\frac{a}{c} + \frac{c}{a}\right)\left(\frac{a}{b} + \frac{b}{a}\right)$.

(*b*) Prove that an equation of the first degree can have only one root.

(*c*) Solve the equation $\left(\frac{x-a}{x+b}\right)^3 = \frac{x-2a-b}{x+a+2b}$

8. In every triangle, the squares on the side subtending an acute angle is less than the squares on the sides containing that angle by twice the rectangle contained by either of these sides, and the straight line intercepted between the perpendicular let fall on it from the opposite angle and the acute angle.

9. Into vessels containing chlorine gas introduce the following substances; describe what happens and say what is formed:—*powdered antimony; heated copper; sodium; blotting paper soaked in turpentine.*

10. What happens when HCl is brought into contact with (1) iron and zinc, (2) MnO (3) MgO, CaO, or ZnO.

11. Define *acid, base, salt, metal.* How can you determine whether a solution is acid or alkaline?

12. What are the modifications of carbon? Describe their properties. Why is carbon called a reducing agent?

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*1st year.*

1. If two circles touch one another internally, the straight line which joins their centres, being produced, shall pass through the point of contact.

2. To divide a given straight line into two parts, so that the rectangle contained by the whole and one of the parts may be equal to the square on the other part.

3. Work out any of the following:—(*a*) construct an isosceles triangle, which shall have one-third of each angle at the base equal to half the vertical angle; (*b*) construct a right angled triangle, having given the hypotenuse and the perpendicular from the right angle on it.

4. Define angle of a segment and distinguish between rhombus and rhomboid. The diagonals of a rhombus are 88 and 234 feet respectively. Find the area. Find also the length of a side and height of the rhombus.

5. The sides of a triangle are *a*, *b*, and *c*. Find the diameter of the circle described round the triangle.

6. Find the area of a regular hexagon which is inscribed in a circle the diameter of which is 100 feet.

7. Find the value of $x$ from the following equation:—

$$\left(x^{3^n}\right)^{\frac{2}{3}}\left\{x^{3^n} + 7a^{3^{n+1}}\left(x^{3^n}\right)^{-2}\right\}^{\frac{1}{3}} = 2a^{3^n}$$

(*b*) prove that $a^0 = 1$.

8. Define rational and surd quantities. Find the square root of $2x + 2\sqrt{2x - a^2}$.

9. Prove that in the equation $a + \sqrt{b} = 2\sqrt{xy} + x + y$, $a = x + y$, $\sqrt{b} = 2\sqrt{xy}$

10. Explain the following terms, giving rough sketches of each where they are used. Floor, bridging joist, struts, trimmers, built beam, frame. Why are the joists strutted in a timber floor. Give sketches of the best kind of wooden floor when joists are strutted. Why are the depths of some of the bridging joists made deeper at intervals.

11. What are the methods of preserving the iron fastenings of timber?

12. Sketch a wooden partition with a doorway in it, showing separately the joints in the frame at the upper corner of the opening.

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## MAY.

### *4th Year.*

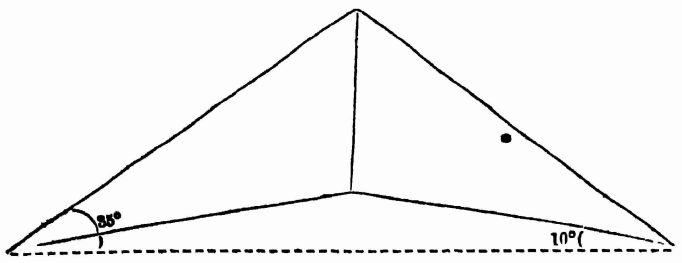
1. (*a*) Distinguish between stress and strain; resistance and strength; dead and live load.

(*b*) Explain the terms:—Breaking weight, ultimate strength, and factor of safety.

2. How are pillars classified according to the ratio of length to depth; and state the modes of their failure.

3. Apply Gordon's formula in finding the area of cross section of a square teak pillar of length 16 feet, fixed at both ends. Working load (W) = 20,000lbs. uniformly distributed, $f_c$ = 12,000lbs., $s$ = 10, $c = \frac{1}{750}$.

4. The marginal figure is a triangular truss of 24 feet span with the tie rod braced up to an inclination of 10° by the king rod. The weight of roof covering supported by one truss is 12,000 lbs. Find by a diagram the stress on the several pieces. Scale 1″=2,000lbs.




5. Describe the tangent galvanometer and show how it is used to measure resistances. Upon what does the resistance of a wire depend?

6. What is a solenoid? What theory of magnetism did Ampère base on the analogy which exists between solenoids and magnets?

7. Enunciate the second Law of motion, and show that if different forces are applied to equal masses, the accelerations generated are proportional to the forces.

8. Find the ratio of the volume of the receiver to that of the barrel in a condenser, if at the end of the third stroke the density of the air in the receiver : its original density :: 3 : 2.

9. Sketch and explain the action of Stephenson's Link-motion.

10. Sketch and explain the action of the distribution and expansion valves in Meyer's valve gear.

11. What do you mean by the term 'cam,' and what is its use? Construct the curve of a cam, so that the velocity of the rod may increase or decrease, as the case may be, according to an arithmetical progression, the angular velocity of the cam being constant.

12. Mention the three modes of application of the screw to a machine. What are the three essential characters belonging to a screw and the three principal conditions required in it. Compare a square-threaded screw with that with v threads.

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*3rd Year.*

1. Describe with a diagram the action of an eccentric. For what purposes are eccentrics used in a steam-engine? What is meant by expansive working? What are its advantages?

2. Describe fully the Bessemer Process of making steel.

3. Give the formulæ of ferrous sulphate; ferric sulphate; iron alum; loadstone; chrome alum; nitrate of bismuth; nickelic hydroxide; iron pyrites. How can you distinguish iron compounds from all others, and how can you tell whether a solution is ferrous or ferric?

4. Give the equations illustrating (1) conversion of potassium dichromate into chromate, (2) conversion of potassium chromate into dichromate.

Give the equation of the reaction when a solution of potassium chromate is added to a solution of barium chloride. What name is given to the precipitate?

5. Prove that $\sin(A + B)\sin(A - B) = \sin^2 A - \sin^2 B$.

6. The altitude of a cloud was observed to be 30°, and that of the sun in the same direction to be 60°, and the distance of the shadow of the cloud from the station of the observer was $2000\sqrt{3}$ feet. Find the height of the cloud?

7. Find the centre of gravity of the figure consisting of an equilateral triangle and a square, the base of the triangle coinciding with a side of the square.

8. The algebraical sum of the moments of two forces which meet at a point, about a point in the plane of the forces, is equal to the moment of their resultant about the same point. Prove this, when the point about which the moment is taken is outside the angle formed by the lines of action of the forces.

9. ACB is a bent lever; the arms CA, CB are straight and inclined to one another at an angle of 135°. When CA is horizontal, a weight P at A just sustains a weight W at B; and when CB is horizontal, the weight W at B requires a weight Q at A to balance it. Find the ratio of Q to P.

10. Briefly state the considerations that should guide you in fixing the direction of a new line of road.

11. What are the objects of metalling the surface of a road. Name some of the substances that are chiefly used in India for metalling purposes.

12. Why are steeper gradients allowable on kutcha than on pucka roads? Illustrate your answer by an example.

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*2nd Year.*

1. Sketch a queen-post truss with all its parts and their names complete, showing the joints of the straining-beam with the principal rafter and queen-post in detail.

2. Define the following terms:—Hip-rafters, jack-rafters, common rafters, and purlins, and show by a sketch how the hip-rafters are joined to the truss.

3. Mention the different ways in which the position of a point is fixed on one side of a chain-line. How is the inclination of two line to one another fixed without using any instrument to read angles, and why, in a chain-survey, is the field divided into triangles only?

4. An area is measured one acre by a chain which is 2″ too long. What is the correct area?

5. A person buys some tea at 3 shillings a pound, and some at 5 shillings a pound; he wishes to mix them so that by selling the mixture at 3*s.* 6*d.* a pound he may gain 10 per cent. on each pound sold. Find how many pounds of the inferior tea he must mix with each pound of the superior?

6. Through a given point within a circle draw the shortest chord.

7. Show that $\sin (A + B) = \sin A \cos B + \cos A \sin B$ and $\cos (A - B) = \cos A \cos B + \sin A \sin B$.

8. Write down the general value of $\theta$ which satisfies the following equations: (1) $\tan^2 \theta + 4 \sin^2 \theta = 3$; (2) $\tan \theta = 4 - 3 \cot \theta$; (3) $\sec^2 \theta - \frac{5}{2} \sec \theta + 1 = 0$.

9. What name is given to the compounds of carbon and hydrogen? Continue to eight members the series of which $CH_4$ is the first. What name is given to such a series? When the breath from the lungs is expelled into lime-water, what happens? Give the equation of the reaction. Should the breathing be continued long, what happens and why? What name is given to the condition of the water now? How would you remedy such a condition?

10. What are the carbonates? From what acid are they derived? Give the equations of the reactions when caustic soda, lime and ammonia solution are treated with this acid.

11. Describe with a diagram the experiment showing carbon monoxide to be a reducing agent; explain how the carbon monoxide you use is obtained, and the use and necessity of each portion of the apparatus you employ.

12. What weight of carbon dioxide will you obtain from 10 ounces of calcium carbonate when treated with H Cl? What other substances are formed and in what quantity? (at, weight of calcium = 40).

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*1st Year.*

1. Explain clearly the following with sketches:—(*a*) external doors with door frames either panelled or glazed; name all their parts and show how they are joined together; (*b*) a sliding sash; (*c*) window and swinging window.

2. What is a staircase; explain the two different kinds of staircases generally built in houses, by short sketches, naming all the different parts of which they are composed.

3. Explain the method of setting out stairs when the building is already erected, or the general plan of it is understood. What is the approximate standard for tread and riser of a staircase.

4. Enunciate the 25th Proposition of the III Book, and give its construction by figures.

5 Enunciate and prove III-22 and its converse, and if the opposite sides of a quadrilateral inscribed in a circle be equal, one of its diagonal must be a diameter of the circle.

6. No two straight lines drawn from the extremities of the base of a triangle to the opposite sides can possibly bisect each other.

7. A room three times as long as it is broad is carpetted at 4*s*. 6*d*. per square yard, and the walls are coloured at 9*d*. per square yard. The respective costs being £8 5*s*. 4½*d*. and 4 guineas. Find the dimensions of the room.

8. A person has a triangular-shaped garden, the base of which contains 200 yards, and divides it into two equal parts by a hedge parallel to the base. Find the length of the hedge.

9. The radius of a circle is 10 feet. The angle of the sector is 120.° Find the area of the segment.

10. On measuring a distance of 32 yards with a rod of certain length, it was found that the rod was contained 41 times with ½ inch over. How many inches will then be over in measuring 44 yards with the same rod?

11. Show that $\left\{\frac{-1+\sqrt{(-3)}}{2}\right\}^n + \left\{\frac{-1-\sqrt{(-3)}}{2}\right\}^n$ is equal to 2 if $n$ be a multiple of 3, and equal to $-1$ if $n$ be any other integer; solve the equation $\left\{\sqrt{a+x}-\sqrt{a}\right\}\left\{\sqrt{a-x}+\sqrt{a}\right\}=nx$.

12. (*a*) Express in the form of the sum of two simple surds the roots of the equation $4x^4 - 4(1+n^2)a^2x^2 + n^2a^4 = 0$.

(*b*) If A and B be the roots of $x^2 - px + q = o$, find the value of $\frac{A}{B} + \frac{B}{A}$, and $A^2 + B^2$, and construct the equation whose roots are $\frac{1}{A}$ and $\frac{1}{B}$.

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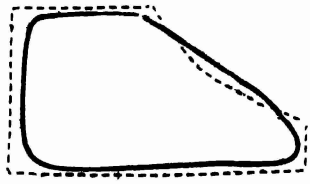
JUNE.

*4th year.*

1. Explain the construction and use of Richard's Indicator.

2. Mention the important facts and operations recorded by the indicator diagram drawn in firm lines in the following sketch. What are the principal causes which make this diagram differ from the "theoretical diagram" shown here in dotted lines:—



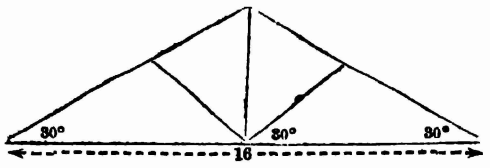
3. Show clearly in a sketch the mechanism employed in an ordinary saw-mill with one vertical saw and a self-acting 'feeder.' In the saw-mill let one tooth of the ratchet wheel be pushed round at each revolution of the fly-wheel, and let the number of teeth in the ratchet wheel = 15, the number of teeth in the pinion = 5, and their distance = 2″; required the length of the cut made by the saw at each downward stroke.

4. Sketch and explain the mechanism of the hand jack.

5. (*a*) Explain the terms "bending moment" and "shearing force."

(*b*) Explain what you understand by the "effective depth" of a girder.

6. Show how to find the breadth of a retaining wall to withstand the pressure of earth against its back, the earth being on a level with its top.




7. The marginal figure is a simple symmetrical king-post truss of 16 feet span. Each truss supports a portion of roof covering weighing 10,000lbs. Find by a diagram the strains on the several pieces.

8. If the truss in question 7 sustains a wind pressure of 3,000lbs. normal to the surface of the roof on one side of it, calculate by a diagram the additional stresses caused thereby.

9. Explain how the following equations are obtained and the meaning of the terms involved :—

$$(1)\ \text{HP.} = \frac{h \times r}{33{,}000 \times t.} \quad (2)\ MS\,(T^\circ - \theta^\circ) = M^1 S^1\,(\theta^\circ - T^{1\circ})$$

10. Describe Ruhmkorff's coil and some of its effects.

11. Two bodies start together from the same point and move uniformly in directions at right angles to each other; one body moves at the rate of 2m. feet per second and at the end of t seconds the distance between them is $(1 + m^2)t$ feet. How far apart will they be at the end of 2t seconds?

12. A cylindrical bell 4 feet deep, whose volume is 20 cubic feet, is lowered into water until its top is 14 feet below the surface of the water, and air is forced into it until it is three-quarters full. What volume would the air in the bell occupy under the atmospheric pressure, the water barometer being at 34 feet?

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*3rd year.*

1. (*a*) Find the number of degrees and minutes in $10^g - 50$.

(*b*) If half a right angle be the unit of angular measurement, express in units of circular measure the angle whose measure is 4.

2. Show that $\sin(A - B) = \sin A \cos B - \cos A \sin B$.

3. If $A\ B\ C$ be the angles of a triangle, prove that—

$$\cot\frac{A}{2} + \cot\frac{C}{2} + \cot\frac{B}{2} = \cot\frac{A}{2} \cdot \cot\frac{B}{2} \cdot \cot\frac{C}{2}.$$

4. Find the radius of a circle inscribed in a triangle in terms of the sides of the triangle.

5. A heavy triangle is suspended by a string passing through a point in one of its sides; determine the position of the point so that the triangle may rest with one side vertical.

6. Compare the greatest and least weights which can be supported by a force on a wheel with a square axle.

7. Describe the common steelyard, and show how to graduate it.

8. Find the ratio of the power to the weight in a system of pullies in which all the strings are parallel and are attached to the weight.

9. Under what circumstances are lead water-pipes dangerous? How would you determine the presence of lead or a lead salt in water? Give the equations of the reactions when minium is treated with nitric acid and lead peroxide with HCl.—

10. Describe fully the extraction of tin from its ore.

11. Lead melts at 326°. Its latent heat of fusion is 5·4. Its specific heat is ·0402 in the solid state and ·0314 in the liquid state; find what mass of water at 0°C. will be raised one-tenth of a degree by dropping into it 100 oz. of melted lead at 350°.

12. Show that the temperature 40°C. and the temperature 40°F. are identical.

The coefficient of expansion of brass is ·0000188; one brass yard measure is correct at 0° and another at 20°C.; find as a decimal of an inch the difference of their lengths at 15°C.

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*2nd year.*

1. Explain the following terms:—
Tread, riser, flight, rough-string, trimmer, fliers, pitching piece, quarter-space and newal.

2. A room 18′ × 13′ in the upper storey of a building is to be divided into two by a wooden partition across the middle, having two door openings in it measuring 3′ 6″ by 7′ each; sketch the partition that can be used in this case.

3. In one of the compartments of the room mentioned in question No. 2, a wooden staircase of 3′ 6″ width is to be built. The height of the roof above the floor of the room is 12 feet. Draw the plan and section of the staircase you think fit for the purpose.

4. Explain clearly the difference in construction and use of a surveying compass and a prismatic compass.

5. A railway train after travelling for one hour meets with an accident which delays it one hour, after which it proceeds at three-fifths of its former rate, and arrives at the terminus three hours behind time; had the accident occurred 50 miles further on, the train would have arrived one hour 20 minutes sooner; required the length of the line, and the original rate of the train.

6. If two straight lines cut one another within a circle, the rectangle contained by the segments of one of them shall be equal to the rectangle contained by the segments of the other.

7. Find the values of—
Sin 75°, sin 15°. Given sin $\alpha = \frac{1}{3}$ and sin $\beta = \frac{2}{3}$; find the value of sin $(\alpha + \beta)$.

8. Find a value of $\theta$ which will satisfy the following equation—

$$\text{Sin } \theta - \cos \theta = \sqrt{\frac{3}{2}}. \quad \text{Sin } \theta - \cos \theta = \frac{\sqrt{3}+1}{2}.$$

9. Give the names, atomic weights, and physical properties of the members of the chlorine family. Write them down in the order of their chemical activities.

Describe how glass-etching may be done by one of the acids of this group.

10. Write out the formulæ of iron pyrites, copper pyrites, galena, gypsum, heavy spar, lead sulphate. From what ore is sulphur chiefly obtained, and where is this ore found? Describe the extraction of sulphur from its ores, indicating wherein the process resembles and differs from the process made use of in making charcoal.

11. Describe the changes sulphur undergoes when it is heated, giving temperatures in Fahrenheit. What happens when boiling sulphur is suddenly cooled? What are the solvents for sulphur? Give the formulæ of the sulphides of hydrogen, oxygen, silver, copper, lead, zinc, antimony.

12. Describe, with diagram, the preparation of sulphur dioxide. In what respects does its bleaching property differ from that of chlorine? What is sulphurous acid, and how is it prepared? Give the general formula of the salts of sulphurous acid. What are they called? Is the acid monobasic or dibasic? Give a reason for your answer.

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*1st year.*

1. What is a centre? Mention several of its parts, and sketch with dimensions the 50′ centre used for Warda bridge.

2. Explain, with sketches, the methods adopted for lowering centres.

3. What do you understand by the term "staging," and sketch the plan and elevation of a simple one?

4. Solve—

(*a*) $\left.\begin{array}{l} x^3 + y^3 + z^3 = 3xyz. \\ x - a = y - b = z - c. \end{array}\right\}$

(*b*) $\sqrt{x^2+9} + \sqrt{x^2-9} = \sqrt{34} + 4.$

(*c*) $2^{x+1} + 4^2 = 80.$

5. (*a*) If $\frac{1}{a} + \frac{1}{b} + \frac{1}{c} = \frac{1}{a+b+c}$, show that

$$\left(\frac{1}{a} + \frac{1}{b} + \frac{1}{c}\right)^{2x+1} = \frac{1}{a^{2x+1} + b^{2x+1} + c^{2x+1}}.$$

(*b*) If $x$ be real, prove that $\frac{2x - y}{2x^2 - 2x - 5}$ can have no real value between $\frac{1}{11}$ and 1.

(*c*) Show that if $\frac{ay - bx}{c} = \frac{cx - az}{b} = \frac{bz - cy}{a}$, then $\frac{x}{a} = \frac{y}{b} = \frac{z}{c}$.

6. Sum the following series:—

(*a*) $1^2 + 2^2 + 3^2 + 4^2 + \ldots\ldots\ldots\ldots + n^2$.
(*b*) $1 - 3 + 5 - 7 + \ldots\ldots\ldots$ to $n$ terms.
(*c*) $1 \cdot 2 + 2 \cdot 3 + 3 \cdot 4 + 4 \cdot 5 + \ldots\ldots\ldots$ to $n$ terms.

7. Enunciate and prove Euclid III. 36.

8. If a straight line touch a circle and from the point of contact a straight line be drawn cutting the circle, the angles which this straight line makes with the line touching the circle shall be equal to the angles which are in the alternate segments of the circle.

9. Two triangles of equal area stand on the same base and on opposite sides; show that the straight line joining their vertices is bisected by the base.

10. Bisect a triangle by a straight line drawn from a given point in one of its sides.

11. The parallel sides of a trapezoid are respectively 16 and 20 feet and the perpendicular distance between them is 5′; it is required to divide the trapezoid into two equal trapezoids. Find the distance of the dividing straight line from the shorter of the parallel sides.

12. Write out Simpson's rule for finding areas.

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## JULY.

### *3rd year.*

1. State the conditions of equilibrium of a lever when the two forces P and W acting at the extremities of a rod are at an angle with each other. A uniform beam whose weight is 130lbs. and length 12 feet has weights of 15lbs. and 25lbs. hung on its ends. Find the point on which the system will balance.

2. Find the condition of equilibrium for a system of pulleys, in which each pulley hangs by a separate string, the strings being parallel, 1*st*, when the pulleys have no weights; 2*nd*, when they have weights.

3. A weight of 20lbs. is supported by a string fastened to a point in an inclined plane, and the string is only just strong enough to support a weight of 10lbs; the inclination of the plane to the horizon being gradually increased, find when the string will break.

4. A force of 15lbs. acting horizontally supports a weight of $5\sqrt{3}$ lbs. on an inclined plane. Find the inclination of the plane to the horizon.

5. State the properties or laws which are assumed as the basis of all reasonings upon fluid action.

6. Any force, however small, may by the transmission of its pressure through a fluid be made to support any weight, however large. Illustrate this by an example.

If the horizontal section of the small cylinder be 7 square inches, and the diameter of the large piston 28 inches, find the lifting power of the machine under a pressure of 1 ton on the small tube.

7. Sketch a segmental arch (the front elevation) of three rings, span 10 feet rise $3\frac{1}{2}$ feet, showing the joints of bricks on one side. Explain the terms by referring to the sketch:—Soffit, intrados, springing lines, haunches, span.

8. What is the horizontal thrust of an arch less than a quadrant of a circle.

9. Describe Marsh's test for arsenic and antimony, showing how they can be distinguished.

10. Six hundred and thirty-two cubic centimetres of air at 43° C. and 1,000 millimetres pressure are heated to 97°C, the pressure being decreased to 740 millimetres. Find the new volume.

11. One brass yard measure is correct at 0° and another at 30°C. Show that the difference between the lengths of the rods at any temperature is constant; find this difference, the coefficient of expansion for brass per degree centigrade being ·0000188.

12. What mass of sand at 10° C. will be raised 4° by mixing with it 300 gm. of lead at ·430°. The melting point of lead is 326° C.; its specific heat in the liquid state is ·0314; in solid state ·0402. Latent heat of lead is 5·4; specific heat of sand is ·215.

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*2nd year.*

1. Draw the plan and elevation of a sash-door with all its parts complete, showing in detail the form of the sash-bars and the modes of fixing the panes of glass and the panel.

2. What do you mean by the terms "centres" and "staging?" Give a sketch for a centre for 30 feet span with no intermediate supports.

3. Mention the different methods of striking centres, and explain the construction and use of sand cylinders in lowering a bridge centre.

4. Distinguish between an apparent and a true bend. Find the amount of correction for curvature and refraction in a distance of 1 mile.

5. (*a*) Solve the equation $\left(\frac{a+x}{a-x}\right)^2 = 1 + \frac{cx}{ab}$.

(*b*) Resolve the following quadratic expression into the product of simple factors:—$2x^2 + x - 6$.

(*c*) For what value of $m$ will the equation $2x^2 + 8x + m = 0$ have equal roots.

6. Describe an isosceles triangle, having each of the angles at the base double of the third angle.

7. Prove by diagram that

$$\tan (A + B) = \frac{\tan A + \tan B}{1 - \tan A \tan B}$$

8. Prove the following relations:—

(*a*) $\frac{\cos a + \cos \beta}{\cos \beta - \cos a} = \frac{\cot \frac{1}{2}(a + \beta)}{\tan \frac{1}{2}(a - \beta)}$

(*b*) $\frac{\tan a - \tan \beta}{\cot a + \tan \beta} = \tan a \times \tan (a - \beta)$.

(*c*) $\text{Sin } a = \sin \beta . \cos (a - \beta) + \cos \beta \sin (a - \beta)$.

9. If wood ashes be treated with water and the solution filtered, how can you prove that the filtered liquid is alkaline, that it contains a carbonate, that the carbonate is potassium carbonate? Describe what happens when potassium or sodium is thrown on water. Is there any difference in the two cases?

10. How much saltpetre, charcoal and sulphur are respectively required in the manufacture of 100lbs. of gunpowder? What percentage of carbon dioxide and nitrogen are respectively given off when 100lbs. of gunpowder are exploded?

11. How would you detect the presence of potassium chloride in a solution of common salt?

How would you prepare ammonium chloride? If ammonium chloride be treated with lime, what is the result? Give the equation of the reaction.

12. How much copper and sulphuric acid are required to make 1,000 lbs. of sulphur dioxide?

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*1st year.*

1. What do you understand by scarfing and fishing? Sketch the joints suitable to resist (1) tension, (2) compression, and (3) cross-strain.

2. Sketch a king-post truss; name all the parts and sketch the joints (1) of the principal rafter with the strut and (2) of the tie-beam with the king-post.

3. Wha rules should be observed in designing stairs?

4. (*a*) Simplify—

$$\frac{5{\cdot}1183}{{\cdot}0141} \text{ of } 22{\cdot}\dot{2} \text{ of } {\cdot}0\dot{9} \text{ of } {\cdot}2\dot{3}\dot{4}$$

(*b*) A in two days can do as much as C in three days, and B in five days as much as C in four days; what time C would require to finish a piece of work which A and B can do in 12 weeks?

5. A is a cask containing 136 gallons of wine, B a cask containing 200 gallons of water; 68 gallons are drawn from each cask, mixed together, and the casks are filled with the mixture. The operation is once more repeated. Find the quantity of wine then contained in each cask.

6. Find the G.C.M. of $2x^4 + 9x^3 + 14x + 3$ and $3x^4 + 14x^3 + 9x + 2$.

7. Solve—

(1) $\dfrac{6x-a}{4x+b} - \dfrac{3x-b}{2x-a} = 0$

(2) $\left.\begin{aligned} x^2-y^2 &= 8x-16 \\ 3xy &= 6x+7y \end{aligned}\right\}$

8. If $a : b :: c : d$, prove that (1) $a + b : a-b :: c + d : c-d$.
(2) $a : a + c :: a + b : a + b + c + d$.

9. The top of the mast of a boat is connected with the bow and stern by two ropes 26 feet and 30 feet long. The length of the boat is 28 feet. Find the height of the mast and its distance from the bow.

10. Inscribe an equilateral and equiangular pentagon in a given circle.

11. The sides about the equal angles of triangles which are equiangular to one another are proportionals; and those which are opposite to the equal angles are homologous sides.

12. On the hypotenuse BC, and the sides CA, AB, of a right angled triangle ABC, squares BDEC, AF and AG are described; show that the squares on DG and EF are together equal to five times the square on BC.

# APPRENTICE DEPARTMENT.

## ANNUAL EXAMINATION, AUGUST 1892.

### ARITHMETIC AND ALGEBRA.

*1st, 2nd and 3rd years.*

1. £52,559-11-11½ is divided equally among 9,007 individuals; express what each will receive in pounds and decimals of a pound.

2. Divide 345·4309838 by 805·7, and find the exact sum of 5·30$\dot{7}$, 15·4$\dot{9}$, 17·$\dot{8}$, ·643 *without reducing the decimals to vulgar fractions.*

3. Simplify—

(*a*) $\frac{4\frac{1}{2}}{5\frac{1}{3}} + \frac{7\frac{1}{2} + 15\frac{3}{5}}{10\frac{1}{2} + 13\frac{1}{3}} + \frac{2}{5} + \frac{3}{7}$ of $2\frac{1}{10}$.

(*b*) $\frac{6{\cdot}6 + \frac{9}{10}}{11{\cdot}0625 - \frac{3}{16} + \frac{9}{8}}$.

4. Reduce £7·6252 + 4·367*s.* + 5·28*d.* to the decimal of £5-10-0.

5. Find by Practice the rent of 39 *ac.* 3 *ro.* 25 *po.* @ £1-15-6 per ac. What is the discount on £186-0-10½ due 4 years and 292 days hence, interest being at 3½% per annum?

6. Goods are bought at 4*s.* 6*d.* per lb.; at what rate must they be sold per ounce to make a profit of 8⅓%?

7. Solve—

(*a*) $(x + 1)(x + 2)(x + 6) = x^3 + 9x^2 + 4(7x - 1)$.

(*b*) $x^2 - x + \frac{72}{x^2 - x} = 18$.

(*c*) $2{\cdot}25x - {\cdot}125 = 3x + 3{\cdot}75$.

(*d*) $\left\{\begin{array}{l} x^3 + y^3 = 126. \\ x^2 - xy + y^2 = 21. \end{array}\right\}$

8. Simplify—

(*a*) $\frac{4x^3 - 10x^2 + 4x + 2}{3x^4 - 2x^3 - 3x + 2}$.

(*b*) $\frac{x^2 - 8x - 9}{x^2 - 17x + 72} \times \frac{x^2 - 25}{x^2 - 1} \div \frac{x^2 + 4x - 5}{x^2 - 9x + 8}$

(*c*) $\frac{1}{8 - 8x} - \frac{1}{8 + 8x} + \frac{x}{4 + 4x^2} - \frac{x}{2 + 2x^4}$

9. Find the H.C.F. and L.C.M. of $x^3 - 9x^2 + 26x - 24$, $x^3 - 12x^2 + 47x - 60$.

10. Find the square root of—

(*a*) $\frac{1}{3}\frac{6}{4} m^2n + 1 + 16m^4 + \frac{4}{3}n + 8m^2 + \frac{4}{9}n^2$.

(*b*) $9x - 12x^{\frac{1}{2}} + 10 - 4x^{-\frac{1}{2}} + x^{-1}$.

11. If $a$, $b$, $c$, $d$ are in continued proportion, show that $b + c$ is a mean proportional between $(a + b)$ and $(c + d)$.

12. A sum of Rs. 100 is divided among a number of persons; if the number had been increased by one-fourth, each would have received 8 annas less: find the number of persons.

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## Geometry and Mensuration.

### 1*st year*.

1. Define plane surface, a scalene triangle, rectangle, reentrant angle, segment of a circle, internal and external segments of a straight line.

2. If the square described on one of the sides of a triangle be equal to the squares described on the other two sides of it, the angle contained by these two sides is a right angle.

3. In a given indefinite straight line, it is required to find a point such that the sum of its distances from two given points on the same side of the straight line shall be the least possible.

4. Divide a given straight line into two parts so that the rectangle contained by the whole and one of the parts may be equal to the square on the other part.

5. In a circle the angle in a semi-circle is a right angle; but the angle in a segment greater than a semi-circle is less than a right angle; and the angle in a segment less than semi-circle is greater than a right angle.

6. Similar triangles are to one another in the duplicate ratio of their homologous sides.

7. The area of a trapezoid is 475 square feet; the perpendicular distance between the two parallel sides is 19 feet. Find the two parallel sides, their difference being 4 feet.

8. The carpeting of a room twice as long as it was broad at 5 shillings per square yard cost £6 2*s*. 6*d*.; and the painting of the walls at 9*d*. per square yard cost £2 12*s*. 6*d*. Find the dimensions of the room.

9. Find the expense of paving a road of a uniform breadth of a yard round the inside of a rectangular piece of ground, the length of which is 85 yards and breadth 56 yards, the cost of paving a square yard being 1*s*. 2*d*.

10. The sides of a triangle are 26 inches, 28 inches, and 30 inches respectively. Find the diameter of the circle described round the triangle in inches.

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*2nd and 3rd years.*

Answer questions 1 to 2, both inclusive, of the above paper, 8, 10 and

11. A right-angled triangle of which the sides are 3 and 4 inches in length is made to turn round on the longer side. Find the volume and the area of the whole surface of the cone thus formed.

12. The frustum of a right cone is 6 feet high, the radius of the smaller end is 2 feet, and the radius of the larger end is 3 feet. Find the position of the plane parallel to the ends which will divide the frustum into two equal parts. Find also the volume of each part.

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TRIGONOMETRY.

*2nd year.*

1. Two angles of a triangle are in magnitude as 2 : 3. If the third angle be a right angle, express the angles of the triangle in each of the three systems of measurement.

2. Show that the angle subtended at the centre of a circle by an arc equal to the radius of the circle is the same for all circle.

3. Find the trigonometrical ratios for the angles of 30°, 45° and 60°.

4. From the summit of a tower whose height is 108 feet, the angles of depression of the top and bottom of a vertical column, standing on a level with the base of the tower, are found to be 30° and 60°. Find the height of the column.

5. Prove the following relations :—

(*a*) $(\text{Cosec}\ \theta - \cot\theta)^2 = \dfrac{1 - \cos\theta}{1 + \cos\theta}$

(*b*) $(\text{Cos}^2\theta - 1)\ (\cot^2\theta + 1) = -1.$

(*c*) $\dfrac{1 + (\text{cosec}\ \theta,\ \tan a)^2}{1 + (\text{cosec}\ a,\ \tan a)^2} = \dfrac{1 + (\cot\theta,\ \sin a)^2}{1 + (\cot a,\ \sin a)^2}$

6. Prove that—

(*a*) $\text{Sin}\ (90° - A) = \cos A.$

(*b*) $\text{Cosec}\ \left(\frac{\pi}{2} + \theta\right) = \sec\theta.$

(*c*) $\text{Tan}\ (\pi + \theta) = \tan\theta.$

7. Solve the following equations:—

(*a*) Tan $\theta = 4 - 3 \cot \theta$.

(*b*) Sin $\theta - \cos \theta = \sqrt{2}$.

(*c*) $\sqrt{3} \sin \theta = \sqrt{3} - \cos \theta$.

8. Show that—

(*a*) Cos $(A - B) = \cos A, \cos B + \sin A, \sin B$.

(*b*) Tan $(A + B) = \dfrac{\tan A + \tan B}{1 - \tan A, \tan B}$

9. Find the values of sin 75°, cos 18° and sec (— 135°).

10. Prove the following relations:—

(*a*) $\dfrac{\text{Sin } A + \sin B}{\text{Cos } A + \text{Cos } B} = \tan \dfrac{A + B}{2}$

(*b*) $\text{Cos}\left(\dfrac{\pi}{3} + \theta\right) + \cos\left(\dfrac{\pi}{3} - \theta\right) = \cos \theta$.

(*c*) $\dfrac{\text{Cos } a + \cos \beta}{\text{Cos } \beta - \cos a} = \dfrac{\cot \dfrac{a + \beta}{2}}{\tan \dfrac{a - \beta}{2}}$

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*3rd year.*

Answer questions 2, 5, 7, 8 and 9 of the above paper, and

11. Show that—

(*a*) $\dfrac{\text{Sin } (a + \beta)}{\text{Sin } a + \sin \beta} = \dfrac{\cos \frac{1}{2}(a + \beta)}{\cos \frac{1}{2}(a - \beta)}$.

(*b*) Sin $3A = 3 \sin A - 4 \sin^3 A$.

(*c*) Solve the equation, tan $2a = 3 \tan a$.

12. (*a*) Given log 2 = ·3010300. Find the logarithms of $\left(\dfrac{2^{60}}{5^{20}}\right)^{\frac{1}{14}}$.

(*b*) Given $\dfrac{4^x}{2x + y} = 8$ and $x = 3y$. Find $x$ and $y$.

13. If $a$, $b$, $c$ be the sides of a triangle, and $A$, $B$, $C$ the angles opposite to them, show that—

(*a*) Cos $A = \dfrac{b^2 + c^2 - a^2}{2bc}$ and

(*b*) Sin $\dfrac{A}{2} = \sqrt{\dfrac{(s - b)(s - c)}{bc}}$ [When $s = \dfrac{a + b + c}{2}$.

14. If $A, B, C$ be the angles of a triangle, prove the following relations:—

(*a*) Tan $A$ + tan $B$ + tan $C$ = tan $A$, tan $B$, tan $C$.

(*b*) In any triangle, prove the following relation:—

$$a \sin (B - C) + b \sin (C - A) + c \sin (A - B) = 0.$$

15. Two sides of a triangle are to each other as 9 : 7, and the included angle is 64° — 12′; determine the other angles. Given log 2 = ·3010300, L tan 57° — 54′ = 10·2025255, L tan 11° — 16′ = 9·2993216; L tan 11° — 17′ = 9·2999804.

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## STATICS.

### *3rd year.*

1. Prove the formula $R^2 = P^2 + Q^2 + 2PQ \cos a$.

Two forces of 2lbs. each, acting at an angle of 60°, have the same resultant as two equal forces acting at right angles. Find these forces.

2. Show that if three forces acting at a point are in equilibrium, each is proportional to the sine of the angle between the other two.

3. Define the term, moment of a force. Prove that the moment of the resultant of two parallel forces about a point is equal to the sum of the moments of the two forces about the same point.

4. Prove that if three forces, which are not parallel, keep a body at rest, their directions meet in a point.

A uniform beam is hinged at its upper end, and is pulled out of the vertical by a horizontal force acting at its lower end. Show by means of a diagram the direction of the force at the hinge.

5. Find the C. of G. of the figure made up of an isosceles triangle, whose base angles are 60°, and of a square described on its base.

6. The beam of a common steel-yard is uniform. The longer arm is 4 times as long as the short arm, the weight is 6″ from the fulcrum, and the moveable weight is 1lb. Find the greatest weight that can be weighed by it. The beam weighs 5lbs.

7. Find the ratio of the power to the weight in the wheel and axle.

8. Show that in one complete revolution of a screw the power is to the weight, as the distance between two successive threads of the screw is to the circumference of the circle described by the point of application of the power.

9. A body on a rough inclined plane is just on the point of slipping. Prove that the coefficient of friction is equal to the tangent of the angle of the plane.

## CHEMISTRY.

*2nd and 3rd years.*

*3rd year will omit the first three questions; the 2nd year the last four.*

1. Describe experiments showing that (1) in some cases heat causes chemical change, (2) in others, simple contact of substances is sufficient, (3) in others, solution aids chemical action.

2. You are given a quantity of dark powder composed of sulphur and iron; how would you determine whether they are mixed mechanically or chemically combined.

3. What is burning? Does it involve a gain or a loss of weight? How can this be determined in the case of a metal such as zinc or lead? How in the case of a candle?

4. State the laws of definite and multiple proportions. What is the evidence in support of these laws, and what theory is based on them? What is Avogadro's Law?

5. Describe briefly one method of preparing each of the following substances:—(*a*) chlorine, (*b*) nitric oxide, (*c*) carbon monoxide, (*d*) phosporus, (*e*) sulphur dioxide.

6. Describe fully an accurate synthetical experiment for determining the composition of water by weight—

840·16 gm. oxygen are required to form 945·439 gm. water. Calculate the percentage composition of water.

7. Distinguish between acids and bases. What are dibasic and tribasic acids? Give examples of such acids and of their salts.

Write down the molecular formulæ of the chlorides, oxides, sulphides of zinc, lead, potassium, iron, arsenic.

8. How many pounds of nitric acid are obtained from 600lbs. of sodium nitrate?

9. Give the names, formulæ, and uses of the chief compounds of sodium and potassium. What are the ammonium salts?

How would you distinguish between solutions of sodium, potassium, ammonium, calcium, strontium?

10. From what ore is silver largely obtained? Describe Pattison's process for extracting silver. How would you determine the quantity of silver in a four-anna piece?

11. 127 gm. of copper are dissolved in nitric acid; what volume of nitric oxide at 14° C· and 1,000 mm. is evolved.

12. A substance has the following percentage composition; what is its molecular formula?

K = 62·9.
N = 11·3.
O = 25·8.

## Surveying.

*2nd and 3rd years.*

1. State briefly how would you survey with the chain only.

2. The boundary of a plot of land is surveyed and plotted. You want to commence the interior survey from a point inside the field. How would you find the position of the point on the map?

3. The area of a piece of land surveyed by an incorrect chain (Gunter's) was 1,742,400 acres. The chain after examining its length was found to be one-fourth of a link too long. Find the correct area.

4. Construct a diagonal scale of $1\frac{1}{3}$ inches to the foot to read to two places of decimals of a yard.

5. What is meant by the correction for curvature and refraction? Why in levelling are these corrections disregarded, and in what case it would practically be necessary to make the corrections?

6. What do you understand by adjustment for collimation, and how is it adjusted in a Dumpy level?

7. Draw up an imaginary level book giving at least 10 readings, two of which are to be back readings, and reduce it to a fixed datum.

8. On a map it is found that 10 acres are represented by 2·25 square inches. Calculate the scale and give its representative fraction.

9. Show how to find the width of a river which is too wide to be reached across by the chain.

10. Describe briefly the method of observing horizontal angles with a theodolite which is in adjustment.

11. A theodolite is divided to 20 minutes on the limb. Describe the vernier to read to 30 seconds.

2nd year will answer from 1 to 9.
3rd ditto ditto 3 to 11.

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## Physics.

*3rd year.*

1. What is the volume at 28° C. of a rectangular prism of iron, the length of whose sides is 30, 40, and 90 cm. respectively, when measured at a temperature of 35° C. (Coefficient of expansion of iron = 0·007209).

2. Explain the action of the compensation balance for chronometers.

3. Sketch and describe an apparatus used for distilling water.

4. What do you know about the following subjects:—
   (*a*) Lagging of steam-cylinders;
   (*b*) steam-jackets;
   (*c*) material of boiler tubes.

These subjects are to be discussed in connection with thermal physics.

5. How did Joule determine the mechanical equivalent of heat? What is its value?

6. The heat of combustion of a certain kind of coal is 6,000 thermal units. How much of the heat given out by a ton of this coal can be at most converted into mechanical energy by means of a steam-engine, if the steam which enters the cylinder has a temperature of 140° C., and is condensed at a temperature of 50° C. after leaving the cylinder?

7. How much water can you evaporate from and at 100° C. by the heat given out by half a ton of that coal?

8. Mention six instances of mechanical energy being converted into heat.

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## ENGINEERING.

### *1st, 2nd and 3rd years.*

N.B.—*Neatness should be considered in awarding marks.*

1. How do you distinguish between scarfing and fishing?

Sketch any joint suitable for beams subjected to cross-strains.

2. Mention several methods for preserving iron-fastenings in contact with timber.

3. Classify the most usual forms of roof used in India.

Give a cross-section of an ordinary terraced roof, and sketch a queen-post truss putting down the names of all its parts.

4. Describe the methods of lowering centres by wedges and sand cylinders.

5. What points must be observed in designing wooden-partitions? Sketch the framing of a partition with a door in the centre.

6. Describe and illustrate a best quality panel-door with frame naming the several parts.

7. What are the requisites to be attended to in planning or laying a stair when the building is already erected? What is the proportion of rise to tread?

8. Note building stones obtainable in the Bengal Presidency.

9. Name the different classes of brick-earths, and state what you know of their composition. Describe the preparation of the clay up to the point at which moulding commences. How does the brick-burner know when the temperature is right?

10. What do you mean by seasoning timber? Describe Davison's desiccating process.

11. Describe the manufacture of wrought-iron from pig-iron or the manufacture of steel by the Bessemer process.

12. Describe Bidder's Earthwork tables. Calculate and explain how to apply the numbers found at the intersection of heights 7 and 17.

13. Explain what is meant by "Bond." Describe and illustrate the different kinds of bond used in brickwork.

14. Explain and illustrate:—Dowel, lewis, screw-piles and coffer-dams.

Explain how would you proceed to erect a pillar in the centre of the Ganges, say near Hooghly.

15. What is the difference between hydraulic lime and cement? Give any practical test to determine whether a lime is hydraulic or not.

1st year to answer questions 1, 2, 3, 4, 5, 6 and 7.
2nd ditto ditto 3, 4, 7, 8, 9, 10, 11 and 15.
3rd ditto ditto 5, 6, 7, 10, 11, 12, 13, 14 and 15.

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## DRAWING.

1st year students will answer the first six questions.

2nd and 3rd-year students will answer questions 2, 4, 5, 6, 7, and 8.

1. Print "SHIBPUR COLLEGE" in half inch vertical block letters, and your name in quarter inch italics.

2. Inscribe a square in a triangle whose sides are $3\frac{1}{2}$, 3 and 2 inches.

3. Draw an ellipse with major axis $3\frac{1}{2}$ inches and minor axis $2\frac{1}{2}$ inches.

4. Construct geometrically without extracting the square root a square which shall contain 8 square inches.

5. (*a*) What is meant by an object being drawn to scale? Explain the term "Representative fraction" of a scale.

(*b*) Construct a simple of $\frac{1}{36}$ to measure feet and inches.

6. A scale of "Bighas" is attached to a vernacular map. The distance between two places known to be 5 bighas apart, measures 2 inches on the map. Construct the corresponding diagonal scale of yards. A bigha = 120 feet.

7. The internal and external diameters of a hollow cylindor three inches long are $1\frac{1}{4}$ and $1\frac{3}{4}$ inches respectively. Draw the projections of the cylinder when lying on the horizontal plane with its axis, making an angle of 45° with the vertical plane.

8. A vessel in the form of a frustrum of a cone is formed of thin sheet metal, the diameters of the top and bottom of the vessel are 12 and 6 inches respectively, and the height of the vessel is 10 inches. The vessel is open at top. Draw to scale of $\frac{1}{4}$ the development of the surface of the vessel.

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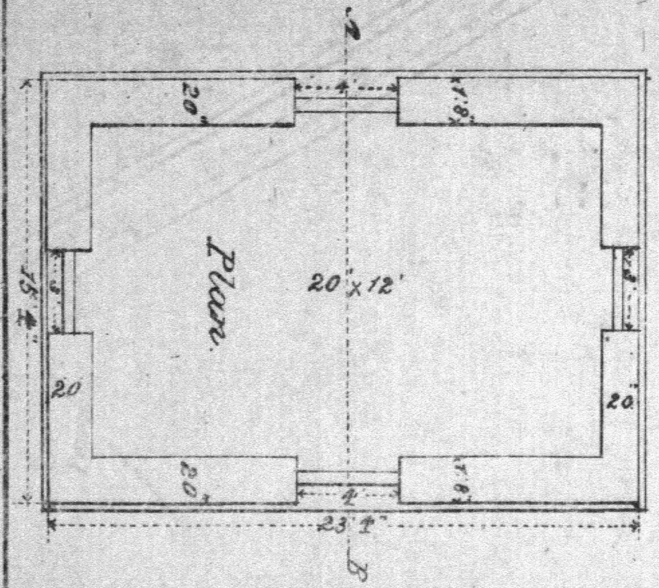
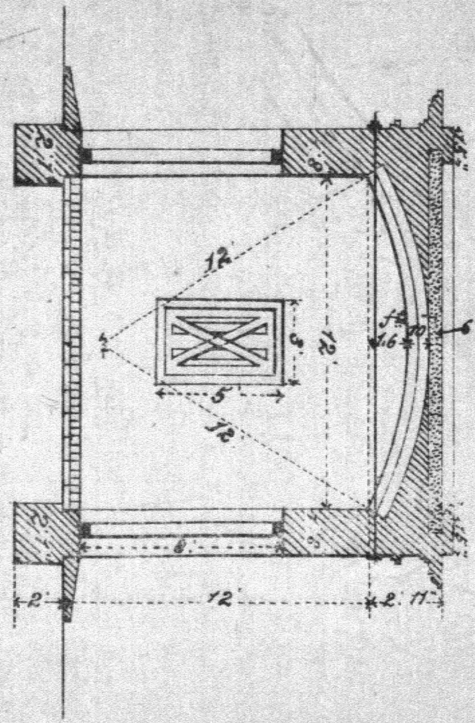
## ESTIMATING.

*2nd and 3rd years.*

# ESTIMATING

## 2nd and 3rd years.




Chowkats of doors
Scantling — 4" × 5"
Dº of windows — 3" × 4"

Scale 8 feet = 1 inch.

2nd year will estimate:—
(1) Foundation masonry.
(2) Superstructure masonry up to 12 feet from ground.
(3) Floor masonry.
(4) Wood work.

3rd year will estimate:—
(1) Foundation masonry.
(2) Superstructure masonry.
(3) Parapet masonry.
(4) Arch masonry in roof.
(5) Spandril filling and parts of walls.
(6) Roof concrete.
(7) Floor masonry.
(8) Wood work.
(9) Cornice with string course in running feet.

# APPRENTICE DEPARTMENT.

## FINAL EXAMINATION, 1892.

### *4th Year.*

#### ARITHMETIC AND ALGEBRA.

1. Find the value of £693-6-6 in dollars and cents; supposing a dollar to be worth 4*s*. 2*d*., and 100 cents going to the dollar.

Find the value of the same sum in rupees at 1*s*. 4*d*. per rupee.

2. Seven men have enough water for 13 days, allowing $1\frac{3}{4}$ pints per man; after five days some water escaped and one man died, and the water still lasted 13 days: how much water was lost?

3. One field contains 769,125 square links: find the difference between its area and that of a field of 37,137 square yards. Give the answer in acres, roods, poles, &c.?

4. A level tract of land 20 miles long and $\frac{3}{4}$ of a mile broad is flooded to a depth of 4 feet: if a cubic foot of water weighs 62lbs., find in tons the weight of water on the land.

5. (*a*) Simplify $2\frac{1}{2} - \dfrac{3\frac{9}{13} \cdot 3}{4 - \frac{3}{4}}$ (*b*) Find the square root of 247579·835476 (*c*). Find the sum of $3\cdot\dot{0}4\dot{7}$, $5\cdot\dot{2}4\dot{9}$, $\cdot 3465\dot{}$ without reducing the decimals to vulgar fractions.

6. By selling out 3 per cent. consols at $102\frac{3}{4}$ and investing the proceeds in a railway stock at 137, a man finds he can double his income: what is the annual dividend on the railway stock?

7. Simplify $\dfrac{10x - 11}{3(x^2 - 1)} - \dfrac{10x - 1}{3(x^2 + x + 1)} + \dfrac{x^2 - 2x + 5}{(x^3 - 1)(x + 1)}$

8. Extract the square root of $4x^6 - 12x^4 + 28x^3 + 9x^2 - 42x + 49$.

Find the H.C.F. and L.C.M. of $20x^4 + x^2 - 1$, $25x^4 + 5x^3 - x - 1$, $25x^4 - 10x^2 + 1$.

9. Solve (*a*) $\dfrac{x - b}{x - a} - \dfrac{x - a}{x - b} = \dfrac{2(a - b)}{x - (a + b)}$

(*b*) $\left.\begin{matrix} 2x + 3y = 1\frac{1}{2} \\ 4x^2 + 9xy + 9y^2 = 11 \end{matrix}\right\}$ (*c*) $a + x\sqrt{2ax + x^2} = b$.

10. Divide $\frac{8-4\sqrt{5}}{\sqrt{5}+1}$ by $\frac{3\sqrt{5}-7}{5+\sqrt{7}}$

11. If P : Q be the sub-duplicate ratio of $P-x : Q-x$, prove that $x = \frac{PQ}{P+Q}$.

12. If $a+b : b+c :: c+d : d+a$, prove that $a = c$ or $a+b+c+d = o$.

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## Geometry and Mensuration.

1. Define parallelogram, trapezium, angle in a segment, escribed circle to a triangle and converse propositions. State the 12th axiom and enunciate the proposition which is the converse of this axiom.

2. (*a*) If one side of a triangle be produced, the exterior angle shall be greater than either of the interior opposite angles.

(*b*) Construct a right angled triangle having given the perimeter and an angle.

3. The sum of the squares on the sides of a parallelogram is equal to the sum of the squares on the diagonals.

4. If from any point without a circle two straight lines be drawn, one of which cuts the circle, and the other touches it; the rectangle contained by the whole line which cuts the circle, and part of it without the circle, shall be equal to the square on the line which touches it.

5. In a right-angled triangle, if a perpendicular be drawn from the right angle to the base, the triangle on each side of it are similar to the whole triangle, and to one another; and prove that the rectangle contained by the segments of the base is equal to the square on the perpendicular.

6. A ladder is placed so as to reach a window 16 feet high on one side of a street, and on turning the ladder over to the other side of the street, it reaches a window 12 feet high; the two positions of the ladder are at right angles to each other. Find the breadth of the street.

7. The span of a bridge the form of which is an arc of a circle, being 96 feet, and the height being 12 feet; find the radius.

8. A room three times as long as it is broad is carpeted at 4*s.* 6*d.* per square yard; and the walls are coloured at 9*d.* per square yard; the respective costs being £8 5*s.* 4½*d.* and 4 guineas: find the dimensions of the room.

9. A pyramid is cut into two pieces by a plane parallel to the base, midway between the vertex and the base: show that one piece is equal to seven times the other.

10. A hemispherical ball of 6 feet diameter is partially buried with its mouth downwards, and in a horizontal position, so that only one-third of the height appears above the ground: find what quantity of earth must be dug out in order to leave the ball entirely uncovered, and just surrounded by a cylindrical wall of earth.

## Trigonometry and Hydrostatics.

1. Make a table of the values of the sine, tangent and secant of 30°, 45°, 60°, 135°.

2. Prove that (1) $\sin (A + B) + \sin (A - B) = 2 \sin A \cos B$.
(2) $\cos (A - B) - \cos (A + B) = 2 \sin A \sin B$.

3. In any triangle prove that $\cos \frac{A}{2} = \frac{\sqrt{s(s-a)}}{bc}$

4. A and B are two points one mile from each other, and C is a distant object. The angles CAB, CBA are measured and found to be 36°·18′ and 120°·27′ respectively. Find the distance of C from B.

5. Find the radius of a circle inscribed in a given triangle.

6. Prove that when a fluid is at rest the pressure at a point is the same in all directions.

7. Show that the resultant pressure on a solid immersed in a fluid is equal to the weight of the fluid displaced, and acts vertically upwards through the centre of the displaced fluid.

A piece of iron completely immersed in water hangs from a spring balance. The pointer of the balance marks 6 lbs. What is the weight of the iron? Specific gravity of iron = 7·2.

8. What is a syphon and how does it work? If a hole were made in the shorter leg what would happen?

9. Describe and explain some simple form of air pump.

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## Statics and Dynamics.

1. If three forces acting at a point be respectively proportional to and parallel to the three sides of a triangle, taken in order, the forces are in equilibrium.

Forces 6, 3, 9, 7 act at a point, and make angles of 45°, 60°, 90°, 120° respectively with a fixed line. Find their resultant. (This may be solved graphically).

2. Show that the resultant of two parallel forces divides a line, cutting these two forces into two parts which are inversely as these forces.

3. Find the centre of gravity of a triangular plate.

4. A body resting on a surface will, or will not be in equilibrium according as the vertical through its C. of G., does or does not fall within its base.

5. The angle of a smooth inclined plane is 30°. Find what force will just prevent a weight of 20 lbs. from sliding (1) when it acts parallel to the plane, (2) when it acts parallel to the base.

6. State the proposition called the parallelogram of velocities. Give examples.

7. Prove the formula $s = \frac{1}{2} ft.^2$

A body falls freely from rest. Find the distance it falls in the third second of its motion.

8. What do you mean by the term "work," and how do you measure it?

Find the work done in filling a tank, 6′ × 6′ × 6′, with water, the bottom of the tank being 9′ above the water-supply.

9. What is gained in power is lost in speed. Illustrate this principle by reference to some one simple machine and to some one of the machines used by you in the workshops.

## Applied Mechanics and Engineering.

1. What and where are the chief stones found in Lower Bengal? Mention their properties and state which of the following you would use them for—(1) road metalling, (2) paving, (3) ordinary building, (4) roofing.

2. Quote specifications for concrete composed of lime, khoa, soorkee to be used in—

(*a*) Foundations of an ordinary building in Calcutta,
(*b*) Constructing a terrace roof,

and state method of mixing and laying to be adopted.

3. Mention the causes of dry and wet rot in timber, and describe the creosoting process for preserving it.

4. Prove that the maximum bending moment produced by a load concentrated at the centre of the span of a beam fixed at both ends is double of what would be produced by the same load if distributed uniformly over the whole length of the beam.

5. Mention the formulæ you would use in determining the size of timber beams necessary to carry a flat terraced floor.

Illustrate by designing sál beams for a floor to cover a room 20′ 0″ × 16′ 0″ per square foot. Beams to be 4′ 0″ apart centre to centre, and to carry a total load of 140 lbs. per square foot composed of 50 lbs. weight of floor including beams, 90 lbs. weight of crown. Safe working intensity of stress to be 2,000 lbs. per square inch. $\frac{\text{depth}}{\text{breadth}} = \frac{1}{\sqrt{2}}$.

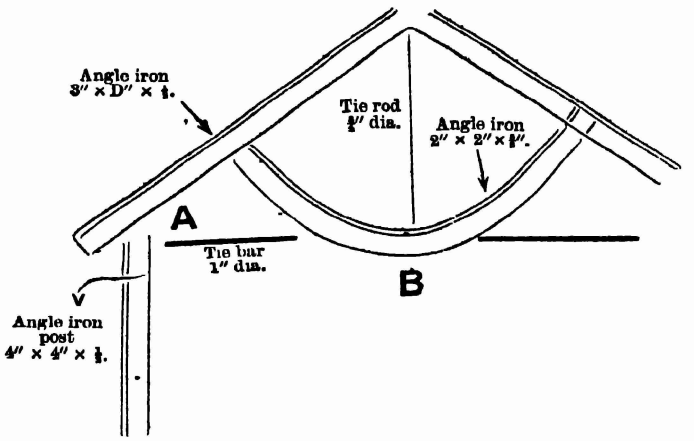
6. Sketch two consecutive courses of a 2½ brick wall in English bond, showing the arrangement at a corner.

7. What do you mean by the line of resistance; within what limit may it deviate, and why?

A pier of masonry 16′ high 20′ long 4′ thick receives at the top at a distance of 1′ from the edge a thrust from an arch. Thrust 160 lbs. per square foot, and inclined at an angle of 60° to the horizon.

Assuming weight of masonry 150 lbs. per cubic foot, draw to a scale of ½″ to 1′, the line of resistance taking imaginary points 4′ apart, and calculate both the maximum and minimum pressure on the foundation at the base.

8. Sketch in freehand the joints you would make at A and B in an iron roof composed as in sketch, and show the arrangement for fastening the corrugated iron on to a purlin supported on the angle iron rafter.




## SURVEYING.

1. What is the representative fraction of the scale 6·336 inches to a mile?

2. Draw a diagonal scale of $\frac{1}{60,000}$, the smallest division on the diagonal to read to the $\frac{1}{100}$th part of a mile; total length of scale to represent six miles.

3. Describe the method of laying a chain on level ground so as to obtain as accurate a measure as possible.

4. In chain surveying when would you consider a triangle "ill-conditioned" and why?

5. Describe the method of reading an angle with the theodolite.

6. If a line has been set out, on a level plane, by poles at equal distances apart, and instead of being straight is an arc of a circle, what part of the theodolite used in setting it out would need adjustment?

7. Name all the adjustments to be made in a dumpy level, and distinguish between permanent and temporary adjustments.

8. To adjust a level for collimation three stations, A, B, C, are taken so that AB = BC; the level is set up at B, and the reading on the staff at A is 3·84, and on the staff at C is 2·76; when the level is put close to A the reading on A is 5·89 and on C 4·79. Is any adjustment required; if so, how would you make it?

9. Explain how to set out curves by the method of off-sets from the tangent.

10. Describe concisely the method of surveying by traversing.

11. To what errors is a prismatic compass liable.

12. Draw a scale, with vernier attached to read to one minute of arc.

*N.B.*—Any ten questions will carry full marks.

## Mechanism and the Steam-engine.

1. Cast-iron should be cut at 16 feet per minute. The travel of a planing machine is 3′, and it makes the return stroke at twice the speed of the cutting stroke. How many strokes per minute should it make when planing cast-iron?

2. Construct two speed pullies giving extreme velocities of 7 to 1 and 4 to 1, the least permissible diameter being 5″.

3. Sketch and explain the action of the lift-pump.

4. Stroke of piston is 4′; connecting rod 9′; construct both curves of piston velocity. If the revolutions are 70 per minute, find the absolute velocity of the piston at each quarter stroke, and also find maximum velocity.

5. The diameter of a piston is 54″. Stroke 3′. Piston approaches within one inch of end of cylinder when at end of stroke.

Boiler pressure = 120 lbs. by gauge. Steam is cut off at half stroke.

Draw a curve representing pressure on cylinder at each one-tenth stroke, assuming Boyle's Law of hyperbolic expansion. State very briefly how this is arrived at in practice.

6. Define the following :—

Dead points—cam—angular velocity—bevil wheels—slide rest—differential pulley—plummer block—outside lap—steam jacket.

7. Sketch the reversing gear as applied to workshop planing machine.

8. Give line sketches of the forms of boilers in common use. What is a galloway tube and why is it advantageous?

9. Sketch—(*a*) an ordinary stuffing box.
(*b*) a pedestal.
(*c*) a safety valve.

*N.B.*—Eight questions to be answered correctly to secure full marks.

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## Drawing.

1. Inscribe a regular pentagon within a circle of 3 inches diameter; and within the pentagon inscribe a square.

2. An elliptic arch of 8 feet span, $2\frac{3}{4}$ feet rise, and $1\frac{1}{2}$ feet thick is formed of eleven voussoirs; draw the elevation of the arch, showing the joints of the voussoirs scale 2 feet = 1 inch.

3. Construct a simple scale of yards. R. F $= \frac{1}{432}$.

4. Construct a decimal diagonal scale of knots, comparative to one of 1 inch to the mile. 1 knot = 6,080 feet.

5. Draw the projections of a right triangular prism upon an equilateral base of 1 inch side, and height 3 inches, when resting on one of the edges of its base, the axis being inclined at an angle of 60° to the horizontal plane, and its horizontal projection inclined at an angle of 40° to the vertical plane.

6. A square hole of 1½ inches side is made on the curved surface of a cylinder of 2½ inches diameter, the axis of the hole bisecting the axis of the cylinder at right angles, and the sides of the hole are parallel and perpendicular to the axis of the cylinder. Draw development of the surface of the cylinder, its height being 3 inches.

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## Chemistry.

1. You are required to fill a gas-holder of 300 litres capacity with hydrogen; the temperature of the air is 86° Fahrenheit, and the atmospheric pressure 750 mm.: describe the apparatus you would employ and give the respective weights of the reagents you would use.

2. Give the names and formulæ of the oxides of nitrogen, showing how they illustrate the law of multiple proportions. Describe the preparation and properties of nitrous oxide and nitric oxide.

3. Describe an apparatus for giving a constant supply of carbon dioxide. What happens when a continuous current of this gas is passed through a solution of lime?

4. Write down the formulæ of all the sulphides of carbon, oxygen, hydrogen, arsenic, iron, tin.

5. Describe briefly the processes in the manufacture of soda ash from common salt.

6. Give a sketch of the extraction of tin from its ore. Where is this ore chiefly found?

7. What is the percentage composition of sodium sulphate and potassium cyanide?

8. A substance has the following percentage composition: what is its molecular formula?

N = 26·17
H = 7·48
Cl. = 66·35

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## Physics.

1. The inner diameter of the cylinder of an engine is 16 inches, the stroke is 2 feet 6 inches, the number of revolutions of the fly-wheel is 55 per minute, and the mean pressure in the cylinder as ascertained from an indicator diagram is 50 lbs. per square inch; find the indicated horse-power of the engine.

2. State the principle of the method known as the method of mixtures, used to determine the specific heat of solids, and show how the method may be used to measure high temperatures.

3. Assuming Boyle's and Gay-Lussac's laws prove that $\frac{PV}{T} = a$ constant, T denoting the absolute temperature. What are isothermal and adiabatic curves?

4. If the heat of combustion of a certain description of coal is 6,500 pound-centigrade units per pound of coal, how much water could be evaporated from and at 100C° by the heat given out by a ton of that coal, if all loss of heat could be avoided.

5. Describe Bunsen's photometer, and show how you would use it.

6. Give a sketch, accompanied by a short description, of any arc lamp known to you.

7. Trace the various forms in which energy appears from the time a quantity of coal is charged into the furnace of a boiler feeding the cylinder of an engine coupled to a dynamo, up to the moment at which the electric current causes the incandescence of the carbon filament of an electric lamp.

5. Explain the following terms—volt, ampere, watt, ohm coulomb, farad, calorie.

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ESTIMATING.

# APPRENTICE DEPARTMENT.

| | Name. | Year. | Present employment. |
|---|---|---|---|
| | Ashini Kumar Mookerjee ... | 1883 | Public Works Department, Bengal, Railway Branch, Darjeeling. |
| | A. E. DeSilva ... | 1883 | |
| | W. Traise ... | 1883 | Public Works Department, 2nd Calcutta Division. |
| | W. M. Halloran ... | 1883 | Public Works Department, Chittagong Hill Tracts. |
| 5 | F. Alone ... | 1883 | Overseer, District Board, Benares. |
| | H. Gilbert ... | 1883 | Public Works Department, Assam. |
| | J. R. Moorhouse ... | 1883 | Foreman, North-Western Railway Workshops, Lahore. |
| | E. B. Walker ... | 1883 | Calcutta Municipality. |
| | H. Bryning ... | 1885 | Overseer, B. S. Railway, Swebo. |
| 10 | C. Perierra ... | 1885 | Calcutta Municipality. |
| | T. Rolston ... | 1885 | Public Works Department, Burma. |
| | Shoshi Bhusan Ghosh ... | 1885 | District Board, Chapra. |
| | Shaik Sudder Ali ... | 1886 | Burma Public Works Department. |
| | G. Branscombe ... | 1886 | Overseer, Arracan Division, Burma. |
| 15 | Bani Kanta Biswas ... | 1886 | Faridpur Municipality. |
| | Sarat Chundra Roy ... | 1886 | Chittagong Public Works Department. |
| | Jogesh Chundra Bose ... | 1886 | Calcutta Public Works Department. |
| | Rajoni Nath Bál ... | 1886 | District Board, Mymensingh. |
| | Basanta Kumar Ghosh ... | 1887 | Midnapore Technical School. |
| 20 | Raghupati Banerjee ... | 1887 | District Board, Purnea. |
| | A. Cuerden ... | 1887 | Overseer, North-Western Provinces. |
| | Harilal Sanyel ... | 1887 | Faridpur District Board. |
| | O. A. Browne ... | 1887 | Public Works Department, Jubbulpur. |
| | J. C. Damzen ... | 1887 | East Indian Railway, Allahabad. |
| 25 | W. Gomes ... | 1887 | Overseer, Public Works Department, Mandalay. |
| | Tranoda Churn Mittra ... | 1887 | Calcutta Public Works Department. |
| | J. H. Roy ... | 1887 | Indian General Steam Navigation Company's steam-ship *Lucknow*. |
| | Upendra Nath Ganguli ... | 1887 | Public Works Department, Calcutta. |
| | Tuniram Borua ... | 1887 | Assam. |
| 30 | Bhuban Chundra Banerjee ... | 1888 | Employed. |
| | Nogendra Nath Chakravarti ... | 1888 | Public Works Department, Bengal, Railways. |
| | Jodunath Biswas ... | 1888 | Sub-Overseer, Public Works Department, Darjeeling. |
| | E. Martin ... | 1888 | Eastern Bengal State Railway, Lungi, Budge-Budge. |

| | Name. | | Year | Present employment. |
|---|---|---|---|---|
| | Heralal Pal | ... | 1888 | Surveyor-General's Office, Calcutta. |
| 35 | Keshub Lal Chatterjee | .. | 1888 | Kidderpore Dock. |
| | R. Rogers | ... | 1888 | Foreman, Lahore Workshop. |
| | C. Hodge | ... | 1888 | Overseer, Midnapore Municipality. |
| | Batta Krishna Singh | .. | 1888 | Calcutta Public Works Department. |
| | Harish Chandra Pal | .. | 1888 | Jalpaiguri Public Works Department |
| 40 | Ashutose Bhattacharjee | .. | 1888 | Chittagong Public Works Department. |
| | A. E Linton | ... | 1888 | East Indian Railway. |
| | G. Morris | ... | 1888 | Public Works Department, Cheera Punji. |
| | A. Bonnar | ... | 1888 | |
| | Surendronath Mittra | .. | 1888 | Deceased. |
| 45 | Sarat Chundra Bose | ... | 1889 | Burn & Co., Howrah. |
| | P. Westerling | .. | 1889 | Deceased. |
| | C. Hottinger | .. | 1889 | Temporary Upper Subordinate, Public Works Department, Mergui. |
| | Kartick Chunder Bose | .. | 1889 | Private works, Calcutta. |
| | H. Michael | .. | 1889 | Mackintosh, Burn & Co. |
| 50 | Degumber Hui | ... | 1889 | District Board, Muzaffarpur. |
| | Rohini Kumar Bhattacharjee | .. | 1889 | Muzaffarpur Railway. |
| | G. M. Gregory | ... | 1889 | Penang. |
| | Jogendra Nath Ganguli | ... | 1890 | Survey Teacher, Patna College. |
| | Nripendra Nath Bose | .. | 1890 | Public Works Department Sub-Overseer, Ranchi. |
| 55 | Srimanta Ch. Chaudhri | ... | 1890 | |
| | Brojendra Kumar Dass | ... | 1890 | Overseer, Karremgunge. |
| | D. W. D'Cruze | ... | 1890 | |
| | C. J. Homer | ... | 1890 | |
| | G. F. Hottinger | ... | 1890 | Temporary Upper Subordinate, Public Works Department, Moulmein. |
| 60 | J. S. O'Connell | ... | 1890 | Overseer, Central Provinces. |
| | Sreekanta Roy | ... | 1890 | Ditto, Local Board, Pirojpur, Barisál. |
| | Romesh Chunder Dutt | ... | 1890 | Sub-Overseer, Public Works Department. |
| | Modhu Sudan Adhicary | ... | 1890 | Sub-Overseer, Public Works Department, Bengal. |
| | Surjee Kumar Chatterjee | ... | 1890 | |
| 65 | Rojoni Kanta Deb | ... | 1890 | Kashipore Municipality Surveyor. |
| | Upendra Nath Hazra | ... | 1891 | |
| | Panch Cowri Mukerjee | .. | 1891 | Sub-Overseer, Public Works Department. |
| | Satis Chundra Mittra | .. | 1891 | |
| | J. G. Dolmar | ... | 1891 | |
| 70 | Gyanendra Nath Banerjee | ... | 1891 | Private Workshop, Sibpur. |
| | Kristo Dhone Ghose | ... | 1891 | Overseer, Public Works Department, Arrah. |
| | R. D. Clark | ... | 1891 | |
| | Haran Chundra Biswas | ... | 1891 | |
| | Hari Narayan Sarkar | ... | 1891 | |
| 75 | Chandra Kanta Chatterjee | ... | 1891 | |
| | A. H. Smellie | .. | 1891 | |

| | Name. | | Year. | Present employment. |
|---|---|---|---|---|
| | Mothura Nath Lahiri | ... | 1892 | |
| | Protap Chander Ghose | ... | 1892 | Public Works, Cuttack. |
| | Sidheswar Shaha | ... | 1892 | |
| 80 | Upendra Nath Datt | ... | 1892 | |
| | Dwark Nath Bose | ... | 1892 | Overseer, District Board, Ranchi. |
| | Gopal Chander Sen | ... | 1892 | Sub-Overseer, Public Works Department, Hazaribagh. |
| | Fazlal Karim | ... | 1892 | |
| | Suresh Chander Banerji | ... | 1892 | Public Works Department, Burma. |
| 85 | Benode Behary Roy | .. | 1892 | |
| | Surjya Coomar Samonta | ... | 1892 | District Board, Dacca. |
| | Deb Lal Ghosal | ... | 1892 | Survey Teacher, Cuttack. |
| | Tara Pado Banerji | .. | 1892 | 3rd grade Overseer, Burma. |
| | Bhola Nath Banerji | ... | 1892 | Ditto ditto. |
| 90 | J. Morrison | ... | 1892 | Public Works Department, Burma. |

*N.B.*—Any inaccuracies in above list should be brought to the notice of the Principal. Passed apprentices out of employ should register their names and addresses in the Principal's office. It is particularly requested that, on any apprentice getting an appointment or changing his appointment, the information be forwarded to the Principal for incorporation in the College Calendar.

# MISCELLANEOUS CERTIFICATE HOLDERS.

## Assistant Engineers.

| | Name. | Year. | Remarks. |
|---|---|---|---|
| | M. King ... | 1865 | Executive Engineer, North-Western Provinces. |
| | H. P. Crane ... | 1865 | |
| | N. A. Richard Chambers ... | 1866 | |
| | C. Twidale ... | 1866 | |
| 5 | Jay Gopal Rakhit ... | 1866 | |
| | Bhola Nath Banerji ... | 1866 | |
| | Mohatap Chunder Mullick ... | 1867 | Surveyor and Assessor, Calcutta Municipality. |
| | Raj Chandra Ghose ... | 1868 | Supervisor, Public Works Department. |
| | Gopal Chandra Bose ... | 1868 | Sub-Engineer, Jessore Division, Public Works Department. |
| 10 | C. J. Middleton ... | 1870 | |
| | J. H. Toogood ... | 1871 | Executive Engineer, 1st Calcutta Division. |
| | F. Murray ... | 1871 | Executive Engineer, Public Works Department. |
| | S. H. Jewett ... | 1871 | Executive Engineer, Assam, and Manager, C. C. S. Railway, Chittagong. |
| | J. M. Harman ... | 1871 | Executive Engineer, North-Western Railway. |
| 15 | G. J. Joseph ... | 1871 | District Engineer, Barcilli. |
| | John George Pew ... | 1871 | |
| | Bhuggobutty Charan Gangooly ... | 1876 | Supervisor, District Board, Rajshai. |
| | Jogendra Chandra Aich ... | 1877 | Engineer, Nepal Government. |
| | Nando Gopal Banerji ... | 1878 | District Engineer, Purulia. |
| 20 | Mohendro Nath Bagchi ... | 1879 | District Engineer, Howrah. |
| | Lalit Mohun Basack ... | 1881 | Also passed L.C.E. |
| | T. B. Byers ... | 1881 | Ditto. |
| | P. W. Byers ... | 1881 | Ditto. |
| | Kapileswar Bhattacharjee ... | 1881 | |
| 25 | Sita Prosono Rai ... | 1882 | Also passed L.C.E. |
| | Mritunjoy Bhattacharjee ... | 1882 | |

## Sub-Engineers.

| | | | |
|---|---|---|---|
| | C. Twidale ... | 1865 | |
| | T. Patterson ... | 1866 | |
| | Gopal Chandra Daw ... | 1866 | |
| | J. D. Douglas ... | 1866 | |
| 5 | J. Joseph ... | 1866 | |
| | J. Atkinson ... | 1866 | |
| | Nolin Behary Ghose ... | 1869 | |

SUB-ENGINEERS—*concld.*

| | NAME. | YEAR. | REMARKS. |
|---|---|---|---|
| | Hem Kantta Deb ... | 1869 | Supervisor, Calcutta. |
| | Raj Kumar Mookerji ... | | |
| 10 | Kedar Nath Roy ... | 1870 | Supervisor, Purulia. |
| | Grish Chundra Das ... | 1870 | |
| | Budhoo Sukhar Banerji ... | 1870 | |
| | Kooraram Ray ... | 1870 | |
| | Gopal Chandra Ghosh ... | 1871 | Supervisor, Sone Circle. |
| 15 | Preo Nath Ghose ... | 1871 | |
| | Chandra Bhusan Dutt ... | 1871 | Supervisor, Sone Circle. |
| | Hem Chandra Mitter ... | 1871 | |
| | Tariney Charan Sircar ... | 1871 | Supervisor, Public Works Department. |
| | Trailokho Nath Sircar ... | 1871 | Ditto ditto. |
| 20 | Charu Chandra Bose ... | 1872 | |
| | Thackoordas Ghosh ... | 1873 | |
| | Akshoy Krishna Bose ... | 1874 | |
| | Radha Nath Sen ... | 1874 | |
| | Soorendro Nath Gupta ... | 1874 | |
| 25 | Sasi Bhusan Mitra ... | 1874 | District Engineer, Dacca. |
| | Giris Chandra Bhor ... | 1874 | |
| | Kenaram Bose ... | 1874 | |
| | Chandra Seekhar Das ... | 1874 | |
| | Kisori Mohan Mookerji ... | 1875 | |
| 30 | Haran Chandra Chatterji ... | 1875 | |
| | Chander Coomar Chatterji ... | 1875 | |
| | Rajendro Nath Neogy ... | 1875 | |
| | Priya Nath Mookerji ... | 1875 | |
| | Rajendro Lal Sarkar ... | 1876 | |
| 35 | Mohini Mohan Bagchi ... | 1876 | |
| | Uma Charan Banerji ... | 1876 | |
| | Balai Chand Rana ... | 1876 | Calcutta Municipality. |
| | Amerto Lal Roy ... | 1876 | |
| | Sures Chunder Gangooly ... | 1876 | Overseer, Public Works Department. |
| 40 | Atul Krishna Mookerji ... | 1876 | |
| | Behari Lal Das ... | 1876 | |
| | Purna Chandra Chatterji ... | 1876 | Sub-Engineer, Public Works Department. |
| | Kedar Nath Gangooly ... | 1876 | |
| | Mohendro Nath Bagchi ... | 1877 | District Engineer, Howrah. |
| 45 | Mohendro Nath Bhattacharjee ... | 1877 | |
| | Ram Lal Bhar ... | 1877 | |
| | Radharomone Guho ... | 1877 | Teacher, Survey School, Dacca. |
| | Abhay Charan Datt ... | 1878 | Calcutta Municipality. |
| | Fakir Chand Mookerjee ... | 1878 | Overseer, District Board, Darbhanga. |
| 50 | Sasi Bhusan Bhattacharjee ... | 1878 | |
| | Brojo Lal Sett ... | 1878 | |
| | Charles William Merton ... | 1879 | |
| | Ram Das Bhattacharjee ... | 1884 | |

OVERSEERS.

| | | | |
|---|---|---|---|
| J. Kelly ... ... | 1865 | |

OVERSEERS—*contd.*

| | NAME. | YEAR. | REMARKS. |
|---|---|---|---|
| | Boycunt Nath Roy ... | 1865 | |
| | Chandra Coomar Chatterji ... | 1865 | |
| | Gopal Chander Daw ... | 1865 | |
| 5 | Ashootosh Mitra ... | 1865 | |
| | Netro Gopal Ray ... | 1865 | |
| | Khetter Nath Ghosal ... | 1865 | |
| | H. E. B. Fox ... | 1865 | |
| | Kartic Chandra Ghose ... | 1866 | |
| 10 | Rojoney Cant Mookerji ... | 1866 | |
| | Laul Gopal Banerji ... | 1866 | |
| | Kally Prosono Mozoomdar ... | 1866 | |
| | Kally Das Das ... | 1866 | |
| | Hem Chandra Banerjee ... | 1866 | |
| 15 | Kristo Chandra Gupta ... | 1866 | |
| | Rakhal Dass Chatterji ... | 1866 | |
| | Galam Ahmed ... | 1866 | |
| | Mohendro Nath Mullick ... | 1866 | |
| | Kaylash Chandra Mookerjee ... | 1866 | |
| 20 | Brindaban Chunder Ghose ... | 1867 | |
| | W. I. Dukes ... | 1867 | |
| | Sashi Bhusan Chatterji ... | 1867 | |
| | Gopal Chandra Mookerji ... | 1867 | |
| | Kassi Kantha Pramanik ... | 1867 | |
| 25 | Jadu Nath Bose ... | 1868 | |
| | Saroda Charan Bose ... | 1868 | |
| | Shurrat Chandra Sandal ... | 1868 | |
| | Nolin Behary Ghose ... | 1868 | |
| | Soshi Bhusan Chatterji ... | 1868 | |
| 30 | Nogendra Chandra Mozoomdar | 1868 | |
| | Roodro Prosono Sing ... | 1868 | |
| | Hera Lal Mitra ... | 1868 | |
| | Toolsy Das Roy ... | 1869 | |
| | Bhoggobutty Gangooly ... | 1869 | |
| 35 | Ram Nath Bhattacharji ... | 1869 | |
| | Siddeshur Chatterji ... | 1869 | |
| | Opendra Lal Gupta ... | 1869 | |
| | Kristo Nath Banerji ... | 1869 | |
| | Narain Chandra Naug ... | 1869 | |
| 40 | Sookmoy Mullick ... | 1869 | |
| | Edward Browne ... | 1869 | |
| | Otool Krishna Mitra ... | 1870 | |
| | Mutty Lal Mozumdar ... | 1870 | |
| | Sree Churn Roy ... | 1870 | |
| 45 | Srinibas Bose ... | 1870 | |
| | Goluck Nath Sen ... | 1870 | |
| | Tara Prasonno Mookerji ... | 1870 | |
| | George A. Laval ... | 1870 | |
| | Koylash Chandra Chowdhury ... | 1871 | |
| 50 | Bhobo Tara Ghose ... | 1871 | |
| | Mohendro Nath Sarkar ... | 1871 | |
| | Avinas Chandra Mookeji ... | 1872 | |
| | Bama Charan Banerji ... | 1873 | |
| | Jogendra Lal Chatterji ... | 1873 | |
| 55 | Umesh Chandra Banerji ... | 1873 | |
| | Baney Madhub Chatterji ... | 1873 | |

OVERSEERS—*contd.*

| | NAME. | YEAR. | REMARKS. |
|---|---|---|---|
| | Aghore Lal Bose ... | 1873 | |
| | Sasi Bhusan Mitra ... | 1873 | |
| | Bepin Behary Mozoomdar ... | 1873 | |
| 60 | Koylas Chandra Mitra ... | 1874 | |
| | Kedar Nath Chowdhury .. | 1874 | |
| | Hera Lal Mitra ... | 1874 | |
| | Mutty Lal Sen ... | 1874 | |
| | Monmotho Nath Chatterji ... | 1874 | |
| 65 | Raj Krishna Mookerji ... | 1874 | |
| | Moti Lal Chowdhury ... | 1874 | |
| | Gunga Charan Gangooly ... | 1875 | |
| | Kartickya Biswas ... | 1875 | |
| | Mohendro Lal Das ... | 1875 | |
| 70 | Jet Narain Dutt ... | 1875 | |
| | Behari Lal Das ... | 1875 | |
| | Krishna Sakha Das ... | 1875 | |
| | Aughore Chandra Ghose ... | 1875 | |
| | Gossein Das Dutt ... | 1875 | |
| 75 | A. Malcolm ... | 1876 | |
| | Sheik Azizar Ruhmon ... | 1876 | |
| | Kunjo Behary Bose ... | 1876 | |
| | Moti Lal Banerji ... | 1876 | |
| | Priya Nath Mitra, No. 1 ... | 1876 | |
| 80 | Jotendra Krishna Basack ... | 1876 | |
| | Hem Chandra Mookerji ... | 1876 | |
| | Ganandra Prosad Roy ... | 1876 | |
| | Chhatradhor Ghose ... | 1876 | |
| | Jodu Nath Banerji ... | 1876 | |
| 85 | Kalidhan Bhattacharji ... | 1876 | |
| | Godadhur Sen ... | 1876 | |
| | Prosonno Coomar Bose ... | 1876 | |
| | Charles William Merton ... | 1876 | |
| | Hari Nath Sen Gupta ... | 1876 | |
| 90 | Monmohun Ghose ... | 1877 | |
| | Sasi Bhusan Dutt ... | 1877 | |
| | Ram Lal Bhor ... | 1877 | |
| | Chuni Lal Sahu ... | 1877 | |
| | Lal Behary Roy ... | 1877 | |
| 95 | Ram Das Bhattacharji ... | 1877 | |
| | Kedar Nath Mozoomdar ... | 1877 | |
| | Avinas Chandra Champati ... | 1877 | Overseer, Darjeeling. |
| | Gholam Ruhmon ... | 1877 | Do., District Board, Gaya. |
| | Preo Nath Mookerji ... | 1877 | |
| 100 | Hem Chandra Nandi ... | 1877 | |
| | Brojo Lal Sett ... | 1877 | |
| | Nivaran Chandra De ... | 1877 | |
| | Hari Das Chatterji ... | 1877 | |
| | Madhub Chunder Chuckerbutty | 1877 | |
| 105 | Debendro Nath Mookerji ... | 1877 | |
| | Khetra Mohan Mookerji ... | 1877 | |
| | Frank Hardy ... | 1877 | |
| | N. Cartland ... | 1877 | |
| | William Radford ... | 1877 | |
| 110 | Daniel Farren ... | 1877 | |
| | H. Williamson ... | 1877 | |

OVERSEERS—*concld.*

| | NAME. | YEAR. | REMARKS. |
|---|---|---|---|
| | Jogendro Nath Ghose ... | 1877 | |
| | A. W. Gantzer ... | 1877 | |
| | Amal Chander Mullick ... | 1877 | |
| 115 | Hari Charan Mookerji ... | 1877 | |
| | Troyluckho Dhor ... | 1877 | |
| | Hem Chandra Das ... | 1877 | Overseer, Public Works Department. |
| | Gyanoda Prosad Ghosal ... | 1878 | |
| | Apurvo Chandra Gangooli . . | 1878 | |
| 120 | Priya Nath Mitra ... | 1878 | |
| | Hari Das Basack ... | 1878 | |
| | Behari Nath Sen ... | 1878 | |
| | Upendro Nath Banerji ... | 1878 | |
| | Upendro Nath Chuckerbutty ... | 1878 | |
| 125 | Nursing Chandra Mookerji ... | 1878 | |
| | Giris Chandra De ... | 1878 | |
| | T. B. Byers ... | 1879 | |
| | Sri Gopal Bose ... | 1879 | Sub-Overseer, Sone Circle. |
| | Atul Chandra Banerji ... | 1879 | |
| 130 | Nobin Chundra Ghose ... | 1879 | |
| | Goluck Chander Mookerji ... | 1879 | |
| | Jogendro Nath Gangooli ... | 1879 | |
| | Hari Charan Bose ... | 1879 | |
| | Norendro Nath Banerji ... | 1879 | |
| 135 | Bama Charan Mullick ... | 1879 | |
| | Jogendro Nath Chatterji ... | 1879 | |
| | Asutosh Ghosh ... | 1879 | |
| | Amin Uddin... ... | 1880 | |
| | Abinas Chunder Roy ... | 1880 | Also passed L.C.E. |
| 140 | Kapileswar Bhattacharjee ... | 1880 | Passed for Assistant Engineer. |
| | Nemi Churn Ghose ... | 1880 | |
| | Gopal Chunder Bhattacharjee... | 1880 | |
| | Russick Lal Mukerjee ... | 1880 | |
| | Lolit Mohun Basak ... | 1880 | Passed L.C.E. |
| 145 | Pran Krishna Sen ... | 1880 | Ditto. |
| | Sita Prosonno Rai ... | 1880 | Ditto. |
| | Bishnuram Chakraverti ... | 1880 | |
| | Satya Churn Banerjee ... | 1881 | Passed L.C.E. |
| | Kali Krishna Mozoomdar ... | 1881 | |
| 150 | Apurva Krishna Sen ... | 1881 | |
| | Kali Gopal Rudra ... | 1881 | |
| | C. E. Lefeuvre ... ... | 1882 | |
| | Annoda Prosad Pal ... | 1882 | |
| | Shama Churn Ganguli ... | 1882 | |
| 155 | Akhil Chunder Marik ... | 1883 | Passed L.C.E. |
| | Lal Chand Mittra ... | 1883 | |
| | Banku Behari Mukerjee ... | ... | Passed L.C.E. |

SUB-OVERSEERS.

| | | |
|---|---|---|
| Saroda Charan Bose ... | 1865 | |
| Mohendro Nath Bhattacharji ... | 1866 | |
| Kally Kristo Dutt ... | 1866 | |

## SUB-OVERSEERS—*contd.*

| | NAME. | YEAR. | REMARKS. |
|---|---|---|---|
| | Nilmoni Banerji ... | 1866 | |
| 5 | Boggobutty Charan Gangooly ... | 1868 | |
| | Saroda Prosad Chatterji ... | 1869 | |
| | Audhor Chandra Roy Chowdhury | 1870 | |
| | Seddeshur Mitra ... | 1870 | |
| | Kashishur Mukerji ... | 1870 | |
| 10 | Chandra Kanthi Mukerji ... | 1870 | |
| | Khetra Mohun Palit ... | 1870 | |
| | Tarrack Nath Gangooly ... | 1870 | |
| | Shib Chander Banerji ... | 1870 | |
| | Bama Charan Roy ... | 1870 | |
| 15 | Eshan Chandra Singh ... | 1871 | |
| | Mohendro Chandra Palit ... | 1871 | |
| | Raj Krisen Ghose ... | 1871 | |
| | Bama Charan Banerji ... | 1871 | |
| | Kali Kristo Roy ... | 1871 | |
| 20 | Kali Prosonno Mookerji ... | 1871 | |
| | Akhoy Kumar Roy ... | 1872 | |
| | Khetra Mohun Mitra ... | 1872 | |
| | Akhoy Kumar Chowdhry ... | 1872 | |
| | Sosi Bhusan Dutt ... | 1873 | |
| 25 | Kedar Nath Chowdhry ... | 1873 | |
| | Surja Kantha Banerji ... | 1874 | |
| | Ram Doyal Roy ... | 1874 | |
| | Hari Lal De Chowdhury ... | 1874 | |
| | Jogendro Nath Mookerji ... | 1874 | |
| 30 | Gris Chandra Banerji ... | 1874 | |
| | Debendra Nath Roy Chowdhry | 1874 | |
| | Rajendra Nath Biswas ... | 1874 | |
| | Hem Chundra Sarkar ... | 1874 | |
| | Chandy Charan Satrah ... | 1874 | |
| 35 | Bedhu Bhusan Trevady ... | 1874 | |
| | Brindaban Chandra Mondul ... | 1874 | |
| | Annodo Charan Brahmo ... | 1874 | |
| | Nil Kantta Dutt ... | 1874 | |
| | Umes Chandra Sen ... | 1874 | |
| 40 | Sita Nath Ghose ... | 1874 | |
| | Ahin Chandra Mookerji ... | 1875 | |
| | Saroda Prosad Samonto ... | 1875 | |
| | Isan Chandra Chowdhry ... | 1875 | |
| | Purno Chunder Daw ... | 1875 | |
| 45 | Abinas Chandra Mullick ... | 1875 | |
| | Prosonc Kumar Bose ... | 1875 | |
| | Gooroo Prosono Banerji ... | 1875 | |
| | Kunjo Behari Bose .. ... | 1875 | |
| | Romun Kristo Ghosh .. | 1875 | |
| 50 | Brojo Pati Banerji ... ... | 1875 | |
| | Modan Mohan Bysack ... | 1875 | |
| | Ram Chandra Bysack ... | 1875 | |
| | Moti Lal Banerji ... | 1875 | |
| | Bhamudra Kumar Ghose ... | 1875 | |
| 55 | Isvar Chandra Das ... | 1875 | |
| | Akhil Chandra Sen ... | 1875 | |
| | Jogendra Nath Ghose ... | 1875 | |
| | Joy Krishna Chatterji ... | 1875 | |

SUB-OVERSEERS—*concld.*

| | NAME. | | YEAR. | REMARKS. |
|---|---|---|---|---|
| | Asvini Kumar Bose | ... | 1875 | |
| 60 | Avinas Chandra Roy | ... | 1876 | |
| | Ram Narain Pal | ... | 1876 | |
| | Sri Kanto Sinha | ... | 1876 | |
| | Ram Doyal Pal | ... | 1876 | |
| | Dharmodas Laha | ... | 1876 | |
| 65 | Chuni Lal Saha | ... | 1876 | |
| | Narain Chander Chatterji | ... | 1876 | |
| | Lal Behary Ray | ... | 1876 | |
| | Chandi Charan Hazra | ... | 1877 | |
| | Govindo Chunder Roy | ... | 1877 | |
| 70 | Umes Chunder Sen | ... | 1877 | |
| | Gopal Chander Bhattacharji | ... | 1877 | |
| | Syma Prosad Rai | ... | 1877 | |
| | Jogendro Kumar Bose | ... | 1877 | |
| | Hera Lal Mookerji | ... | 1877 | |
| 75 | Deno Nath Gui | ... | 1877 | |
| | Avinas Chandra Bose | ... | 1877 | |
| | Amieruddin | ... | 1878 | |
| | Chuni Lal Mitra | ... | 1878 | |
| | Kedar Nath Nag | ... | 1878 | |
| 80 | John James FitzWilliam | ... | 1878 | |
| | Chandra Kantha Basack | ... | 1878 | |
| | Upendra Nath Kanjilal | ... | 1878 | |
| | W. Bowers | ... | 1878 | |
| | Guru Doyal Kundu | ... | 1878 | |
| 85 | Kali Charan Mookerji | ... | 1878 | |
| | Bepin Behary Bose... | ... | 1879 | |
| | Bama Charan Mookerji | ... | 1879 | |
| | Romesh Chandra Sen | ... | 1879 | |
| | Kaisiki Charan Gupta | ... | 1879 | |
| 90 | Atul Chandra Mookerji | ... | 1879 | |
| | Bani Madhub Mullick | ... | 1879 | |
| | Avinas Chandra Roy | ... | 1879 | |
| | Asutosh Chatterji | ... | 1879 | |
| | Sudhamay Dutt | ... | 1880 | |
| 95 | Monmotho Nath Mukerjee | ... | 1880 | |
| | Haripodo Chatterjee | ... | 1880 | |
| | Sivadas Bhattacharjee | ... | 1881 | |
| | Lal Chand Mittra | ... | 1881 | Also passed as Overseer. |
| | Sarat Chunder Roy | ... | ... | |
| 100 | Annoda Prosad Sarkar | ... | 1881 | Passed L.C.E. |
| | Tarini Churn Roy | ... | 1881 | |
| | Mohim Chunder Rudra | ... | 1882 | |
| | Banwari Lal Banerjee | ... | 1883 | |
| | Chandra Kanta Bose | ... | 1890 | |

*Certificates granted under Director of Public Instruction's No.* 5677, *dated* 23*rd July* 1884.

THIRD GRADE OVERSEERS.

| | | | |
|---|---|---|---|
| Kuloda Nanda Mukerjee | ... | 1885 | |

THIRD GRADE OVERSEERS—*concld.*

| | NAME. | YEAR. | REMARKS. |
|---|---|---|---|
| | Preo Nath Roy ... | 1886 | |
| | Jadu Nath Mittra ... | 1886 | |
| | Surendra Nath Sen... ... | 1886 | |
| 5 | Troylocko Nath Dutt ... | 1888 | |
| | Gopal Chundra Roy ... | 1888 | |
| | Nebaran Chundra Chatterjee ... | 1888 | |
| | Surja Kumar Das ... | 1889 | |
| | Makhan Lal Sarkar ... | 1890 | |
| 10 | Chanchal Chundra Banerjee ... | 1890 | |
| | Jogendra Lal Pal ... | 1890 | |
| | Notobar Ghosal ... | 1891 | |
| | Kaliprosonno Sen ... | 1891 | |
| | J. Morrison ... | 1891 | |
| 15 | Mohindro Chandra Paul ... | 1892 | |
| | Gopeswar Roy ... | 1892 | |
| | Gobindo Chandra Boral ... | 1892 | |

*Certificates granted under Director of Public Instruction's No.* 4221, *dated* 15*th May* 1884.

SUB-OVERSEERS.

| | | | |
|---|---|---|---|
| | Raj Kumar Ganguli ... | 1884 | |
| | Jadub Chunder Chatterjee ... | 1885 | |
| | Bepin Behari Gupta ... | 1885 | |
| | Sitanath Bhuttacharjee ... | 1885 | |
| 5 | Nikunja Behari Bose ... | 1886 | |
| | Bejoy Krishna Mukerjee ... | 1886 | |
| | Nritya Gopal Bhuttacharjee ... | 1886 | |
| | Raj Krishna Mandal ... | 1887 | |
| | Heera Lal Santra ... | 1887 | |
| 10 | Chanchal Chundra Banerjee ... | 1887 | Also passed as 3rd grade Overseer. |
| | Kaliprosonno Sen ... | 1887 | Ditto ditto. |
| | Baroda Kanta Thakoor ... | 1888 | |
| | Sidheswar Mozoomdar ... | 1888 | |
| | Gopal Chundra Lahiri ... | 1888 | |
| 15 | Upenda Nath Sen Gupta ... | 1888 | |
| | Mohendra Nath Gossamy ... | 1888 | |
| | Kamini Kanta Bhuttacharjee ... | 1888 | |
| | Upendra Nath Chandra ... | 1888 | |
| | Annoda Churn Ghose ... | 1888 | |
| 20 | Protap Chunder Ghose ... | 1889 | |
| | Dakshinaranjan Muchaddi ... | 1889 | |
| | Tarak Nath Chowdhry ... | 1891 | |
| | Soshibhusan Bhuttacharjee ... | 1891 | |
| | Pulin Behari Ghose ... | 1891 | |
| 25 | Brindaban Chundra Mukerjee ... | 1891 | |
| | Pulin Behary Shaha ... | 1891 | |
| | Jaggut Bundhoo Gupta ... | 1891 | |
| | Brojendra Nath Chatterjee ... | 1891 | |

*Certificates granted under Director of Public Instruction's No.* 4221, *dated* 15*th May* 1884—concld.

SUB-OVEESEERS—*concld.*

| | NAME. | | Year. | REMARKS. |
|---|---|---|---|---|
| | Saroda Prosad De | ... | 1891 | |
| 30 | Surendra Nath Banerjee | ... | 1891 | |
| | Ashutosh Chatterjee | ... | 1891 | |
| | Nogendranath Chatterjee | ... | 1891 | |
| | Lalbehary Roy | ... | 1891 | |
| | Debendra Nath Sen Gupta | ... | 1891 | |
| 35 | Jogendra Nath Ghose | ... | 1891 | |
| | Surjya Kumar Roy | ... | 1891 | |
| | C. Raynard | ... | 1891 | |
| | Panchanun Ganguli | ... | 1891 | |
| | Purna Chandra Dutt | ... | 1891 | |
| 40 | Dakshineswar Chatterjee | ... | 1891 | |
| | Sarat Chandra Das | ... | 1892 | |
| | Jogendro Nath Mookerji | ... | 1892 | |
| | Ashutosh Bhattacharjee | ... | 1892 | |
| | Punna Lal Banerji | ... | 1892 | |
| 45 | Nekunjo Behari Gupta | ... | 1892 | |
| | Nobo Kumar Shaha | ... | 1892 | |
| | Bidhu Bhusan Sen | ... | 1892 | |
| | Sasi Bhusan Nag | ... | 1892 | |
| | Behari Lal Ghose | ... | 1892 | |
| 50 | Debendro Nath Bhattacharji No. 2 | | 1892 | |
| | Rungo Lal Mookerji | ... | 1892 | |
| | Debendro Nath Bhattacharji | ... | 1892 | |
| | Gokul Chandra Roy | ... | 1892 | |
| | Keshub Lal Gangooly | ... | 1892 | |
| 55 | Girindro Chandra Ghose | ... | 1892 | |
| | Durga Pado Bose | ... | 1892 | |
| | Akshoy Kumar De | ... | 1892 | |
| | Russick Lal Dutt | ... | 1892 | |
| | Peari Mohun Mookerji | ... | 1892 | |
| 60 | Neebaran Chandra Das | ... | 1892 | |
| | Jotindro Krishna Bose | ... | 1892 | |

# ACCOUNTS.

*Examination qualifying for admission to the Subordinate Accounts Branch for 4th Grade, P. W. D.*

## SUBJECTS FOR EXAMINATION.

| | Full marks. | Minimum pass marks. |
|---|---|---|
| Writing (neatness, clearness and rapidity) ... | 100 | 50 |
| Dictation (spelling, punctuation, &c.) ... | 100 | 50 |
| Arithmetic (whole course) ... ... | 240 | 160 |
| Mensuration (*a*) (whole book) ... ... | 60 | 30 |
| Book-keeping (*b*) Mercantile ... ... | 100 | 50 |
| Total ... | 600 | 400 |

Minimum required in all papers collectively.

(*a*) Todhunter's Mensuration for Beginners.
(*b*) " Book-keeping " by Ball and Hamilton.
" Book-keeping " by double and single entry by W. Inglis (Chamber's Educational Course).

*The marks gained by candidates who fail will not be published.*

1. The examination is held annually at the Civil Engineering College, Sibpur, on the 1st Monday in June. The examination will be conducted either at the College or by an Examiner, Public Works Accounts (including Railway and Telegraph) in Bengal, Assam, and Burma only.

Candidates will not be examined in any of the Calcutta offices.

2. Candidates not in Government employ who wish to be examined at the College must forward their applications direct to the Principal; those employed in Government offices through the head of their office, who will forward the application to the Principal.

All applications must reach the Principal 30 days before the date of examination.

3. The candidate should apply to an Examiner of Public Works Accounts not later than 30 days previous to the date fixed for the examination, and obtain his consent to conduct the examination if examination at the College is not convenient. The application must be forwarded by the candidate, not direct to the Principal, but through the Examiner.

All applications must be accompanied by a fee of Rs. 10 and the following certificates.

Certificates may be submitted in original, or true copies attested by an officer of the Engineer or Accounts Branch, but none will be returned:—

(1) Certificate of good character signed by applicant's immediate official superior, or by the instructor under whom he has been educated, or by some other superior under whom he may have been brought up or employed, or to whom he may be well known. (This certificate must have special reference to the two years immediately preceding the application.)

(2) Certificate that candidate is under 25 years of age (not required if candidate is in permanent Government employ, or an employé under District Boards).

(3) Certificate that the application is in candidate's handwriting.

It will rest with the Principal of the College, on a consideration of these certificates, to decide whether the candidate should be registered for the examination, or whether his application should be rejected.

5. Copies of examination papers are not procurable except those that are issued for examination. These need not be returned.

6. Each examination is complete in itself. A candidate who has failed in an examination, and presents himself for examination on a subsequent occasion, must undergo the full examination, and furnish a fresh fee and certificates.

7. Passed candidates should apply, not to the Principal of the College, nor to the Accountant-General, Public Works Department, but direct to the Examiner of Public Works Accounts in the Province or Railway under whom they may desire to be employed.

8. It must be distinctly understood that the passing of this examination does not give any claim to an appointment, and that in making appointments preference will be given to qualified persons who are already employed in the Department.

# ACCOUNTANTS.

| | Names. | Year. |
|---|---|---|
| | **4th Grade Accountants.** | |
| | Chandi Charan Ghose ... | 1866 |
| | Haran Chundra Bose ... | 1866 |
| | Womesh Chandra Chatterjee | 1866 |
| | Nundo Lal Sen ... | 1866 |
| 5 | Bhoobun Mohan Chatterjee ... | 1866 |
| | Mohendra Nath Chatterjee ... | 1866 |
| | Dwarka Nath Pal ... | 1866 |
| | Chandra Nath Simlye ... | 1866 |
| | Ram Kamal Sircar ... | 1866 |
| 10 | Nilmadhub De ... | 1866 |
| | Kally Kamal Sircar ... | 1866 |
| | Gopal Gobindo Chowdry ... | 1866 |
| | Mohesh Chandra Bose ... | 1866 |
| | Sreenath Ghose ... | 1866 |
| 15 | Sasthi Charan Mittra ... | 1866 |
| | W. Fleming ... | 1866 |
| | A. Rangiyald ... | 1866 |
| | Sashidhur Baruah ... | 1866 |
| | R. H. Smith ... | 1866 |
| 20 | Norman Andrews ... | 1867 |
| | Issan Chundra Mittra ... | 1867 |
| | Nundo Lal Mukerjee ... | 1867 |
| | Koylas Chundra Chatterjee ... | 1867 |
| | William Jones ... | 1867 |
| 25 | Soorji Kumar Banerjee .. | 1867 |
| | Daniel Pereira ... | 1867 |
| | Richard M. Slane ... | 1867 |
| | E. A. Coello ... | 1867 |
| | George A. Laval ... | 1867 |
| 30 | F. W. Hurst ... | 1867 |
| | J. Jacob ... | 1867 |
| | W. Martin ... | 1867 |
| | W. P. Kelly ... | 1867 |
| | Kally Gopal Mukerjee ... | 1867 |
| 35 | Kala Chand Mukerjee ... | 1867 |
| | Gopal Chandra Dutta ... | 1868 |
| | Bonomally Chatterjee ... | 1868 |
| | J. H. Richards ... | 1868 |
| | Radharaman Set ... | 1868 |
| 40 | Tarini Charan Chatterjee ... | 1868 |
| | Womesh Chandra Ghosh ... | 1868 |
| | C. E. Jacobs ... | 1868 |
| | Aloysius D. Reddie ... | 1868 |
| | Ambica Charan Chatterjee ... | 1868 |
| 45 | Kally Prosonno Banerjee ... | 1868 |
| | A. Calder ... | 1868 |
| | Bundiram Chatterjee ... | 1868 |
| | Gopal Chundra Dass ... | 1868 |
| | Jagat Chundra Shome ... | 1868 |
| 50 | Ashutosh Mittra ... | 1868 |

| | Names. | Year. |
|---|---|---|
| | **4th Grade Accountants—*continued.*** | |
| | Nibaran Chundra Chatterjee. | 1868 |
| | Poorno Chundra Bhuttacharjee | 1868 |
| | R. A. Coello ... | 1868 |
| | Juggobandhu De ... | 1869 |
| 55. | Nundo Lall Bhuttacharjee .. | 1869 |
| | Prassonno Kumar Pal ... | 1869 |
| | Bholanath Dass ... | 1869 |
| | Debendra Nath Mullik ... | 1869 |
| | Jadunath Pal ... | 1869 |
| 60 | Kally Krishna Chatterjee ... | 1869 |
| | William Thomson ... | 1869 |
| | Andrew Bald ... | 1869 |
| | Womesh Chandra Mukerjee ... | 1869 |
| | W. McReddie ... | 1869 |
| 65 | W. N. Shilstone ... | 1869 |
| | J. D. Gregory ... | 1869 |
| | Indraram Baruah ... | 1869 |
| | J. R. Coles ... | 1870 |
| | Kally Prosonno Roy ... | 1870 |
| 70 | Ramram Dutt ... | 1870 |
| | Shyam Sundra Patnaik ... | 1870 |
| | Bhoggobutty Charan Mukerjee | 1870 |
| | Prossonno Kumar Dutt ... | 1870 |
| | Durga Charan Banerjee ... | 1870 |
| 75 | Lal Mohan Dass . ... | 1870 |
| | Girish Chandra Deb ... | 1870 |
| | Radha Mohan Dass ... | 1870 |
| | C. A. James ... | 1870 |
| | R. DeCruze ... | 1870 |
| 80 | H. J. A. Palmer ... | 1870 |
| | Woma Charan Mitra ... | 1870 |
| | Aghore Nath Ghosal ... | 1870 |
| | Radhika Prosad Sircar ... | 1870 |
| | Ambika Charan Mittra ... | 1870 |
| 85 | Ish n Chandra Dutt ... | 1870 |
| | J. A. Freitus ... | 1870 |
| | Ishan Chandra Kundu ... | 1870 |
| | Kshettra Mohan Tarafdar ... | 1871 |
| | Kanti Chundra Mukherjee ... | 1871 |
| 90 | Dwarkanath Sen ... | 1871 |
| | Bishnu Charan Mukerjee ... | 1871 |
| | A. Percy ... | 1871 |
| | J. W. Bridge ... | 1871 |
| | Shyama Charan Ghose ... | 1871 |
| 95 | Chundra Nath Banerjee ... | 1871 |
| | A. Wilson ... | 1871 |
| | C. F. Stevens ... | 1871 |
| | Debendra Nath Dutt ... | 1871 |
| | H. C. Kingh ... | 1871 |
| 100 | Geo. Lambert ... | 1872 |
| | Mohendra Nath Chatterjee ... | 1872 |
| | A. R. Kalberer ... | 1872 |
| | Ghoneshyam Bhuttacharjee ... | 1872 |

| | Names. | Year. |
|---|---|---|
| | **4th Grade Accountants—*continued.*** | |
| | Satcowry Mukerjee ... | 1873 |
| 105 | E. Lumsden ... | 1873 |
| | Akhil Chandra Mukerjee ... | 1873 |
| | A. A. Daniel ... | 1873 |
| | Jadu Nath Chatterjee ... | 1873 |
| | E. J. P. Fynn ... | 1873 |
| 110 | Brojo Mohan Aditya ... | 1873 |
| | Bhibiram ... | 1873 |
| | Poorno Chandra Sen ... | 1873 |
| | Rameswar Dass ... | 1873 |
| | Bidhinath Chatterjee ... | 1873 |
| 115 | Mohima Chundra Bhaduri ... | 1873 |
| | J. F. Chew ... | 1873 |
| | T. T. Durmalingum ... | 1873 |
| | Gopi Mohan Banerjee ... | 1873 |
| | Pasupati Charan Bose ... | 1873 |
| 120 | Krishna Chundra Bose ... | 1873 |
| | Madan Mohan Ghose ... | 1873 |
| | Sidhesswar Bose ... | 1873 |
| | Raj Kissen Ghose ... | 1873 |
| | H. O. Daniel ... | 1873 |
| 125 | Ashutosh Singha ... | 1873 |
| | Edward Hyde Phillips ... | 1873 |
| | Kally Krishna Ghosal ... | 1873 |
| | Bidhubhusan Mukerjee ... | 1873 |
| | Isaac Purnanundo Roy ... | 1873 |
| 130 | E. P. O'Conner ... | 1873 |
| | Womesh Chandra Pal ... | 1874 |
| | Sodanando Behera ... | 1874 |
| | Chandra Kanta Ghose ... | 1874 |
| | Moonshi Abdul Burr ... | 1874 |
| 135 | Sashi Sikhar Banerjee ... | 1874 |
| | Nundo Lal Mukerjee ... | 1874 |
| | Kally Charan Mittra ... | 1874 |
| | Krishna Kumar Son ... | 1874 |
| | Jas. Alfred Pain ... | 1874 |
| 140 | Eugene Cox ... | 1874 |
| | Adya Nath Mittra ... | 1874 |
| | Ramdas Sircar ... | 1874 |
| | Raj Mohan Ganguli ... | 1874 |
| | Shyama Charan Ghose ... | 1874 |
| 145 | Kartikeya Biswas ... | 1874 |
| | Sarat Chandra Chakraverti ... | 1874 |
| | Debendra Nath Mukerjee ... | 1874 |
| | Ashutosh Bose ... | 1874 |
| | C. H. Ramanua Naidu ... | 1874 |
| 150 | Bootee Lal ... | 1874 |
| | Nilambar Bose ... ... | 1875 |
| | Bhutnath Mukerjee ... | 1875 |
| | Banimadhub Mukerjee ... | 1875 |
| | Kunja Behari Dutt ... | 1875 |
| 155 | Akshoy Kumar Ghose ... | 1875 |
| | Dwarkanath Chatterjee ... | 1875 |
| | Walter R. Monks ... | 1875 |

| | Names. | Year |
|---|---|---|
| | 4th Grade Accountants—*continued.* | |
| | J. S. Johnstone ... | 1875 |
| | Nundolal Dass ... | 1875 |
| 160 | Satya Charan Chatterjee ... | 1875 |
| | Henry Arthur Nelson ... | 1875 |
| | Upendra Nath Ganguli ... | 1875 |
| | Nemai Charan De ... | 1875 |
| | John Simpson ... | 1875 |
| 165 | Kedar Nath Chakraverti .. | 1875 |
| | Sarat Chandra Mozoomdar ... | 1875 |
| | Saroda Prosad Chatterjee ... | 1875 |
| | Ambika Charan Sircar ... | 1875 |
| | Brojonath Bhuttacharjee ... | 1875 |
| 170 | Golab Chand Lal ... | 1875 |
| | Sarat Chandra Roy .. | 1875 |
| | Hem Chandra Ghose ... | 1875 |
| | Purna Chandra Bose ... | 1875 |
| | Madho Roy Ganesh ... | 1875 |
| 175 | S. G. A. Phillips ... | 1875 |
| | Kissori Bollov Roy ... | 1875 |
| | Woma Charan Banerjee ... | 1875 |
| | Gopal Chandra Dutt ... | 1875 |
| | Nilratna Banerjee ... | 1876 |
| 180 | Sitala Charan Ghose ... | 1876 |
| | Abdur Rubb ... | 1876 |
| | Kally Bhusan Banerjee ... | 1876 |
| | Upendra Nath Dutt ... | 1876 |
| | Janoki Prosad Tewari ... | 1876 |
| 185 | Anando Naik ... | 1876 |
| | Phillip Macklin Flanney ... | 1876 |
| | Bhudar Banerjee ... | 1876 |
| | Ananda Gopal Guin ... | 1876 |
| | Dimbadhur Dass ... | 1876 |
| 190 | Kedarnath Dass ... | 1876 |
| | George P. Pritchard ... | 1876 |
| | P. G. Jordan ... | 1876 |
| | Annoda Charan Rose ... | 1876 |
| | Arthur William Namey ... | 1876 |
| 195 | Sylvester Herbert ... | 1876 |
| | Akshoy Chandra Karmokar | 1876 |
| | Nobin Chandra Banerjee ... | 1876 |
| | Samuel Hammond Watling ... | 1876 |
| | H. Leonard ... | 1876 |
| 200 | Kedar Nath Ghose ... | 1876 |
| | William Hart ... | 1876 |
| | E. H. Telfer ... | 1876 |
| | John Martin Sarkies ... | 1876 |
| | W. C. Phillips ... | 1876 |
| 205 | Mohamed Akrum ... | 1876 |
| | Kirtiram Boruah ... | 1876 |
| | Shib Chandra Dutt ... | 1876 |
| | Ambika Charan Chatterjee ... | 1876 |
| | Hem Kally Chatterjee ... | 1876 |
| 210 | Hari Charan Sircar ... | 1876 |
| | K. Sunderramiah Pantolu ... | 1877 |

| | Names. | Year. |
|---|---|---|
| | **4th Grade Accountants—*continued.*** | |
| | Jas. Schofield ... | 1877 |
| | C. Visnanadhuna Moodelier ... | 1877 |
| | Bamapodo Roy ... | 1877 |
| 215 | Gopal Chundra Dutt ... | 1877 |
| | G. Ewing ... | 1877 |
| | Kshettra Nath Banerjee ... | 1877 |
| | Francis T. G. Valker ... | 1877 |
| | Sidhesswar Bose ... | 1877 |
| 220 | Bama Charan Dutt ... | 1877 |
| | Shiv Krishna Pundit ... | 1877 |
| | Abinas Chundra Banerjee ... | 1877 |
| | James Grassmann ... | 1877 |
| | Purusottam Bhuttacherjee ... | 1877 |
| 225 | M. G. Lackersteen ... | 1877 |
| | Jogendra Chundra Deb ... | 1877 |
| | Nursing Chundra Banerjee ... | 1877 |
| | Saroda Prosad Mittra ... | 1877 |
| | R. A. Freitas ... | 1877 |
| 230 | M. V. Muttusami Iyer ... | 1877 |
| | Anthony Bernard Mariano ... | 1877 |
| | William Baran Twidale ... | 1877 |
| | Annoda Prosad Mukerjee ... | 1877 |
| | Joggeshwar Ghose ... | 1877 |
| 235 | Jogesh Chundra Mukerjee ... | 1877 |
| | John Edwin Cooney ... | 1878 |
| | Chundra Nath Mittra ... | 1878 |
| | Francis Walter Eicke .. | 1878 |
| | Radhagobindo Bysak ... | 1878 |
| 240 | Khiroda Kumar Sing ... | 1878 |
| | Trailokya Nath Chakraverti... | 1878 |
| | Haripodo Chatterjee ... | 1878 |
| | Amullyaratan Mukerjee ... | 1878 |
| | Raja Ram ... | 1878 |
| 245 | Bishnu Das ... | 1878 |
| | Bhairo Sahay ... | 1878 |
| | Rai Beshoon Dutt ... | 1878 |
| | Tincowry Ghose ... | 1878 |
| | Alexander Diniveddie ... | 1878 |
| 250 | Imam Bux .. | 1878 |
| | Goordit Mull ... | 1878 |
| | C. R. Dela Hayde ... | 1878 |
| | Michael J. Senaes ... | 1878 |
| | Chundra Kanta Bose ... | 1878 |
| 255 | Nutt Mull ... | 1878 |
| | Dobendra Nath Chakraverti... | 1878 |
| | William Thomas Middleton... | 1878 |
| | Grant Nicholas ... | 1878 |
| | H. P. Dick ... | 1878 |
| 260 | Ambika Charan Banerjee .. | 1878 |
| | Radhanath Roy Chowdry ... | 1878 |
| | Protap Chundra Gupta ... | 1878 |
| | Haridas Roy ... | 1878 |
| | Atul Krishna Mukerjee ... | 1878 |
| 265 | Kshettra Nath Bose ... | 1878 |

| | Names. | Year. |
|---|---|---|
| | **4th Grade Accountants—*continued.*** | |
| | H. A. Campbell ... | 1878 |
| | C. D. Howard ... | 1878 |
| | Bama Charan Ghose ... | 1878 |
| | Rai Charan Chatterjee ... | 1878 |
| 270 | Hari Mohan Banerjee ... | 1878 |
| | J. A. Farrell ... | 1878 |
| | Frederick Pruce ... | 1878 |
| | Mangu Ram ... | 1878 |
| | Shyama Charan Chakraverti... | 1878 |
| 275 | Jadub Chundra Bhomik ... | 1878 |
| | Bani Madhub Chatterjee ... | 1878 |
| | Shyama Prosad Roy ... | 1878 |
| | Nritya Gopal Bose ... | 1878 |
| | Upendra Nath Mittra ... | 1878 |
| 280 | Charles Thomas D'Souza ... | 1878 |
| | Seetaram Sen ... | 1878 |
| | Bhogobutty Charan Chatterjee | 1878 |
| | Arthur Strachan Wyman ... | 1879 |
| | George Johnstone ... | 1879 |
| 285 | William N. Ryan ... | 1879 |
| | Haradev Prasada ... | 1879 |
| | Upendra Nath Banerjee ... | 1879 |
| | Bowhani Charan Mittra ... | 1879 |
| | Fred. W. Rogers ... | 1879 |
| 290 | Kumud Nath Chatterjee ... | 1879 |
| | Goneshi Lal ... | 1879 |
| | Nobogopal Singha ... | 1879 |
| | Nepal Chundra Mukerjee ... | 1879 |
| | Tincowry Chatterjee ... | 1879 |
| 295 | Edward Welton Dover ... | 1879 |
| | Fred. Charles Welton Dover | 1879 |
| | Bhutnath De ... | 1879 |
| | Edward Marshall ... | 1879 |
| | Harprosad Pundit ... | 1879 |
| 300 | Prosadi Lal ... | 1879 |
| | Chuni Lal ... | 1879 |
| | Ernest Blewett ... | 1879 |
| | Kissori Mohan Sanyel ... | 1879 |
| | Sarat Chundra Mittra ... | 1879 |
| 305 | James Maurice Hartmann Swiney. | 1879 |
| | Panch Cowry Ghose ... | 1879 |
| | Edmond James Chas Dundon | 1879 |
| | H. Ewing ... | 1879 |
| | Prankrishna Mukerjee ... | 1879 |
| 310 | Brojendra Kumar Sircar ... | 1879 |
| | Kheroda Prosad Banerjee ... | 1879 |
| | Ramjehan Ghose ... | 1879 |
| | Umaprosad Roy ... | 1879 |
| | Jagodishwar Bose ... | 1879 |
| 15 | Manna Lal ... | 1879 |
| | Trekimlal Kesowlal ... | 1879 |
| | Kedar Nath Chatterjee ... | 1879 |
| | Annoda Prosad Banerje ... | 1879 |

| | Names. | Year. | |
|---|---|---|---|
| | **4th Grade Accountants—*continued.*** | | |
| | Durgadas Banerjee ... | 1879 | |
| 320 | S. O. Shaughnessy ... | 1879 | |
| | Lakshiram ... | 1879 | |
| | G. Evans ... | 1879 | |
| | Chundra Kanta Promanik ... | 1879 | |
| | Gouri Ram ... | 1879 | |
| 325 | Madho Ram ... | 1879 | |
| | Basanto Kumar Mukerjee .. | 1879 | |
| | Mainickjee Burjuijee ... | 1879 | |
| | Gangadhar Anant ... | 1879 | |
| | James Johannes ... | 1879 | |
| 330 | Shyama Charan Ghose ... | 1879 | |
| | Charles Wight ... | 1879 | |
| | Roger N. Beveridge ... | 1879 | |
| | V. Solomon ... | 1879 | |
| | Girish Chandra Nag Sircar ... | 1879 | |
| 335 | Arthur Andrews ... | 1880 | |
| | Prosonno Kumar Sen ... | 1880 | |
| | Jonardon Mukerjee ... | 1880 | |
| | Janakinath Roy ... | 1880 | |
| | Kally Prosonna Roy ... | 1880 | |
| 340 | Ramranjan Mukerjee ... | 1880 | |
| | Baladeb Gosain ... | 1880 | |
| | Assini Kumar Bose ... | 1880 | |
| | William Joseph Burvett ... | 1880 | |
| | Frederick Stuart Porter ... | 1880 | |
| 345 | Paramessari Dass ... | 1880 | |
| | Jowala Singh ... | 1880 | |
| | Ram Chand ... | 1880 | |
| | Narain Singh ... | 1880 | |
| | Memnanjee Fundoojee ... | 1880 | |
| 350 | Srish Chundra Ghose ... | 1880 | |
| | John Joseph McCann ... | 1880 | |
| | Bama Charan De ... | 1880 | |
| | Bejoygovindo Chowdry ... | 1880 | |
| | Soshi Bhusan Bhuttacharjee | 1880 | |
| 355 | Sarada Prosad Bhattacharjee | 1880 | |
| | Lalla Nanak Chand ... | 1880 | |
| | Shangsor Chander Banerjee ... | 1880 | |
| | Gustadji Dhanjishah Kagsadia | 1880 | |
| | Albert Clifford Owen ... | 1880 | |
| 360 | Sarabjee Bamanjee ... | 1880 | |
| | Abhoy Charan Roy ... | 1880 | |
| | Choony Lall Magan Lall ... | 1880 | |
| | Ram Chander Bhote ... | 1880 | Passed under section IV, paragraphs 59 and 60, Chapter II, P. W. D. Code of 1878. |
| | James D. Rozario ... | 1880 | |
| 365 | T. McCann ... | 1880 | |
| | Uma Prosad Bagchi ... | 1880 | |
| | Amrito Lall Bose ... | 1880 | |
| | Notobor Mukerjee ... | 1880 | |
| | Nondo Lall Bhattacharjee ... | 1881 | |
| 370 | Sidheswar Roy ... | 1881 | |
| | W. J. Dunn ... | 1881 | |
| | Mohendro Nath Roy ... | 1881 | |

| | Names. | | Year. | |
|---|---|---|---|---|
| | **4th Grade Accountants—*continued.*** | | | |
| | Dwarka Nauth Sen | ... | 1881 | |
| | Kedar Nauth Biswas | ... | 1881 | |
| 375 | David O'Dowda | ... | 1881 | |
| | George Augustus Damzen | ... | 1881 | |
| | Aghore Nauth Dutt | ... | 1881 | |
| | Nobin Krisna Bhattacharjee | ... | 1881 | |
| | Uma Sankar | ... | 1881 | |
| 380 | J. Corrigan | ... | 1881 | |
| | Kamikhya Nauth Banerjee | ... | 1881 | |
| | Moolji Bhagwan Shett | ... | 1881 | |
| | A. C. C. McLeish | ... | 1881 | |
| | Baidya Nauth Bhattacharjee | ... | 1881 | |
| 385 | Jogot Chander Mukerjee | ... | 1881 | |
| | A. Ganguly | ... | 1881 | |
| | William Kelly | ... | 1881 | |
| | Gour Gopal Dey | ... | 1881 | |
| | Ranga Nauth Kasi Nauth Fausi | | 1881 | |
| 390 | Kirti Chander Chatterjee | ... | 1881 | |
| | Ganoda Prosad Ganguly | ... | 1881 | |
| | Francis George Harris | ... | 1881 | |
| | Jules Bell | ... | 1881 | |
| | Atul Krisna Dutt | ... | 1881 | |
| 395 | Behari Lal Chatterjee | ... | 1881 | |
| | T. Subramoney Aun | ... | 1881 | |
| | Arthur McLean | .. | 1881 | |
| | Keshub Chander Singhi | ... | 1881 | Passed under section IV, paragraphs 59 and 60, Chapter II, W. P. D. Code of 1878. |
| | Dasorothi Banerjee | ... | 1881 | |
| 400 | Lalla Mulk Roy | ... | 1882 | |
| | Amor Nauth Ganguly | ... | 1882 | |
| | F. W. McGrath | ... | 1882 | |
| | Richard Frederick Drame | ... | 1882 | |
| | Lalla Nibu Ram | ... | 1882 | |
| 405 | Pundit Gopi Nauth | ... | 1882 | |
| | Sree Nauth Mittra | ... | 1882 | |
| | Keshob Chander Ghose | ... | 1882 | |
| | C. Narsiah | ... | 1882 | |
| | P. Varejanabhudu Naidu | ... | 1882 | |
| 410 | Cheddi Lal | ... | 1882 | |
| | Bhowani Charan Boral | ... | 1882 | |
| | Shashi Bhusan Pal | ... | 1882 | |
| | William Lemon | ... | 1882 | |
| | E. L. Richards | ... | 1882 | |
| 415 | Daniel Bates | ... | 1882 | |
| | Upendro Nath Mittra | ... | 1882 | |
| | Narayan Chander Roy | ... | 1882 | |
| | John Green | ... | 1882 | |
| | W. H. E. Turner | ... | 1882 | |
| 420 | Sarat Chander Mitter | ... | 1882 | |
| | Nezaiudin | ... | 1882 | |
| | Autul Behary Das | ... | 1882 | |
| | Mohini Mohon Bhattacharjee | | 1882 | |
| | Oscar William Malletti | ... | 1882 | |
| 425 | Rajendro Nauth Mukerjee | ... | 1882 | |
| | Alexander M. Carson | ... | 1882 | |

| | Names. | Year. | |
|---|---|---|---|
| | **4th Grade Accountants—*continued.*** | | |
| | John Thobwing ... | 1882 | |
| | Allice Alex. Philbert ... | 1882 | |
| | Sam Joachim ... | 1882 | |
| 430 | Cecil Joachim ... | 1882 | |
| | Vallah Hargovindo Almarram Bhuckhanwalla ... | 1882 | |
| | Shoshi Bhusan Pal ... | 1882 | |
| | Nicholas John Jebb ... | 1882 | |
| | Makhan Lal Roy ... | 1882 | |
| 435 | Bireswar Mukerjee .. | 1882 | |
| | John Rodda Dunn ... | 1882 | |
| | Herbert Butterfield ... | 1882 | |
| | Probodh Chander Gupta ... | 1882 | |
| | Madho Ram ... | 1882 | |
| 440 | Archibald Gregory ... | 1882 | |
| | Thomas Michell Shaw ... | 1882 | |
| | James Argyle Smith ... | 1882 | |
| | Reginald Peyton Dunlop Burbridge ... | 1883 | |
| | Tranada Charan Mittra ... | 1883 | |
| 445 | Augustus DeSouza ... | 1883 | |
| | Reginald Medlycott ... | 1883 | |
| | Nathu Jamnadas ... | 1883 | |
| | Sarat Chander Chowdhury ... | 1883 | |
| | Nobin Chander Sen ... | 1883 | |
| 450 | Annada Prosad Dutt ... | 1883 | Passed under section IV, paragraphs 59 and 60, Chapter II, P. W. D. Code of 1878. |
| | Richard A. Creenumey ... | 1883 | |
| | Mahomed Jalaluddin ... | 1883 | |
| | Bhogobote Charan Mukerjee ... | 1883 | |
| | Alexander Fernie ... | 1883 | |
| 455 | Pundit Modon Mohon ... | 1883 | |
| | Abdul Goni ... | 1883 | |
| | Shoshi Kumar Mozoomdar ... | 1883 | |
| | Kedar Nath De ... | 1883 | |
| | Hari Nauth Singha ... | 1883 | |
| 460 | Thakur Das ... | 1883 | |
| | Le C. Rostan ... | 1883 | |
| | Kailaspotty Banerjee ... | 1883 | |
| | Moti Lal Mukerjee ... | 1883 | |
| | Debi Singh ... | 1883 | |
| 465 | Adhor Nauth Banerjee ... | 1883 | |
| | Hira Lal Roy Chowdhury ... | 1883 | |
| | James Thomas Evans ... | 1883 | |
| | J. Geo. B. Armour ... | 1883 | |
| | E. L. Mendes ... | 1883 | |
| 470 | Damodor Dutt ... | 1883 | |
| | Karam Chand ... | 1883 | |
| | Earnest H. D'Cruz ... | 1883 | |
| | Govindo Ram ... | 1883 | |
| | Ram Chander Chaturwedi ... | 1883 | |
| 475 | Chirag Deen ... | 1883 | |
| | Tarapodo Ghose ... | 1883 | |
| | James Younan ... | 1883 | |
| | Chatturbhooj Dobey ... | 1883 | |

| | Names. | Year. | |
|---|---|---|---|
| | **4th Grade Accountants—*continued.*** | | |
| | Parjaram Naratam Das Adhyaree ... | 1883 | |
| 480 | Hari Charan Dutt ... | 1883 | |
| | Ram Chander Banerjee ... | 1883 | |
| | Pundit Niranjan Nauth ... | 1883 | |
| | Mul Raj Khoola ... | 1883 | |
| | Pundit Ishar Das ... | 1883 | |
| 485 | Bapalal Kikabhai ... | 1883 | |
| | Moola Ram ... | 1883 | |
| | Kirtibas Bhattacharjee ... | 1883 | |
| | Joges Chunder Chatterjee ... | 1883 | |
| | Louis R. St. Romaine ... | 1883 | |
| 490 | Makando Ram ... | 1883 | |
| | Mohon Lal ... | 1883 | |
| | Monohor Lal ... | 1883 | |
| | Hem Chunder Ghose ... | 1883 | |
| | A. Belletty ... | 1883 | |
| 495 | Sham Narayan ... | 1883 | |
| | Jamsetjee Eduljee ... | 1883 | |
| | Ishar Dass ... | 1883 | |
| | Gunda Singh Moonshi .. | 1883 | |
| | Tulsi Ram ... | 1883 | |
| 500 | Charles Raymond Martin ... | 1883 | |
| | Okhoy Kumar Roy ... | 1883 | |
| | Ganga Shohay ... | 1883 | |
| | R. Krishna Sawmey Naicker ... | 1883 | |
| | Sohan Lall ... | 1884 | Passed under section IV, paragraphs 59 and 60, Chapter II, P. W. D. Code of 1878. |
| 505 | Nripendro Nath Roy ... | 1884 | |
| | Jerome Andrew ... | 1884 | |
| | R. Dowling ... | 1884 | |
| | Ram Narain Banerjee ... | 1884 | |
| | Karim Baksh ... | 1884 | |
| 510 | Charles Lodrick ... | 1884 | |
| | Ahmed Din ... | 1884 | |
| | Edmond D'Rozario ... | 1884 | |
| | Troylukhyo Nath De ... | 1884 | |
| | Novin Chander Bhattacharjee | 1884 | |
| 515 | Durga Prosuda ... | 1884 | |
| | Deepa Shah ... | 1884 | |
| | H. C. V. Sage ... | 1884 | |
| | Henry Walter Fegudo ... | 1884 | |
| | C. Muirhead ... | 1884 | |
| 520 | Ananto Ram ... | 1884 | |
| | C. S. Murphy ... | 1884 | |
| | Mahomed Abdoollah ... | 1884 | |
| | Tarapodo Ghose ... | 1884 | |
| | Balkrisna Trinbock ... | 1884 | |
| 525 | Dabendro Nauth Roy ... | 1884 | |
| | Ganga Ram ... | 1884 | |
| | Kassim Beg ... | 1884 | |
| | Barkat Alli ... | 1884 | |
| | Mohendro Nauth Ghose ... | 1884 | |
| 530 | W. W. De Lattoyde ... | 1884 | |
| | Debi Doyal ... | 1884 | |

| | Names. | Year. | |
|---|---|---|---|
| | 4th Grade Accountants—*continued.* | | |
| | C. L. Jose ... | 1884 | Passed under section IV, paragraphs 59 and 60, Chapter II, P. W. D. Code of 1878. |
| | Gowri Ditta ... | 1884 | |
| | Barada Kanta Chowdhury ... | 1884 | |
| 535 | Khetra Mohon Bose ... | 1884 | |
| | Troylukyo Nauth Chakerbutty | 1884 | |
| | Hakim Din .. | 1884 | |
| | V. E. Neros .. | 1884 | |
| | Frederic Chaplin Nisbet .. | 1884 | |
| 540 | Badhwa Mul .. | 1884 | |
| | Hera Nand ... | 1884 | |
| | Shyam Lal ... | 1884 | |
| | Kannyhia Lall ... | 1884 | |
| | Lakhpot Roy .. | 1884 | |
| 545 | Bipin Behary Dey ... | 1884 | |
| | T. Narain Swamey Pillay ... | 1884 | |
| | Madho Lall ... | 1884 | |
| | Edmund Cannon Maylan ... | 1885 | |
| | Arthur Henry Hammill .. | 1885 | |
| 550 | Dinshaw Manickji ... | 1885 | Passed under section IV, paragraphs 59 and 60, P. W D. Code of 1878. |
| | Ram Lal Roy ... | 1885 | |
| | Jugal Kisore Byasack . | 1885 | |
| | Ram Chander Govind Talvalkar | 1885 | |
| | Gopal Das ... | 1885 | |
| 555 | Chandra Mohon Das .. | 1885 | |
| | Dharma Das Mukerjee ... | 1885 | |
| | Herambo Nauth Chatterjee .. | 1885 | |
| | Bhutto Behary Dhor ... | 1885 | |
| | Brojo Lal Sanyel .. | 1885 | |
| 560 | Bama Charan Chakerbutty ... | 1885 | |
| | Amor Nauth Pandit ... | 1885 | |
| | Makhan Lal Ghose ... | 1885 | |
| | Bhola Nauth ... | 1885 | |
| | Bipin Behary Batavyal ... | 1885 | |
| 565 | Rajendro Nauth Banerjee ... | 1885 | |
| | Denis O'Hearn ... | 1886 | |
| | G. H. Coleman ... | 1886 | |
| | Poorna Chander Dey ... | 1886 | Passed under section IV, paragraphs 59 and 60, Chapter II, P. W. D. Code of 1878 |
| | Nil Prosonna Ghose ... | 1886 | |
| 570 | Kiran Chander Banerjee ... | 1886 | |
| | Rash Behary Addi ... | 1886 | |
| | Gerald Leith Godwin ... | 1886 | |
| | Bipin Behary Banerjee ... | 1886 | |
| | Poorna Chander Chatterjee .. | 1886 | |
| 575 | R. J. Morton ... | 1886 | |
| | Robert Walsh ... | 1886 | |
| | Bidhu Bhusan Banerjee ... | 1886 | |
| | Radha Kanto Roy ... | 1886 | |
| | Munshi Willoyut Hossain Khan | 1886 | |
| 580 | Debendro Nauth Bose ... | 1886 | |
| | Ashutose Neogy ... | 1886 | |

| | Names. | Year. | |
|---|---|---|---|
| | 4th Grade Accountants—*continued.* | | |
| | Robert F. George ... | 1887 | |
| | Jiban Krishna Chander ... | 1887 | |
| | Hyginus Dommerric ... | 1887 | |
| 585 | Gracias ... | 1887 | |
| | Bipin Behary Chandra ... | 1887 | |
| | Nil Kanto Chatterjee ... | 1887 | |
| | Girish Chander Gupta ... | 1887 | |
| | Dennis O'Sullivan . ... | 1887 | |
| 590 | Moti Lall Sen ... | 1887 | |
| | A. D. Rozario ... | 1887 | |
| | Michael Charles Edward Dorris | 1887 | |
| | Akhoy Kumar Banerjee ... | 1887 | |
| | Arthur Joseph George ... | 1887 | |
| 595 | A. Rainford ... | 1887 | |
| | Leonard Colthurst ... | 1887 | |
| | John S. Riley ... | 1887 | |
| | Haraprosad ... | 1887 | |
| | Edward Bertram James ... | 1887 | |
| 600 | Radha Charan Banerjee ... | 1887 | |
| | Kaliprosonna Banerjee ... | 1887 | |
| | Kunjabehary Lal ... | 1887 | |
| | Mohendro Nath Das ... | 1887 | |
| | Shoshi Bhusan Dutt ... | 1887 | |
| 605 | Bacharam Audhicary ... | 1887 | |
| | Beniprosad ... | 1887 | |
| | Kalidas Bose ... | 1887 | Passed under Appendix C, paragraphs 12 and 18 of P. W. D. Code of 1886. |
| | Uma Nauth Singh ... | 1888 | |
| | James William Fillinger ... | 1888 | |
| 610 | James H. Cameron ... | 1888 | |
| | Ashutosh Bhattacherjee ... | 1888 | |
| | William O'Cesar ... | 1888 | |
| | E. W. Hall ... | 1888 | |
| | George Hamilton ... | 1888 | |
| 615 | Shushil Kumar Bose ... | 1888 | |
| | Jogendro Kumar Bhadra ... | 1888 | |
| | Walter Harold Hodges ... | 1888 | |
| | Mihir Chander Dutt ... | 1888 | |
| | W. A. Samuel ... | 1888 | |
| 620 | Ashutosh Mookerjee ... | 1888 | |
| | A. Cum Sone ... | 1888 | |
| | Abinash Chander Ghosh ... | 1888 | |
| | A. Vaughan ... | 1889 | |
| | Robert Cresswell Keating ... | 1889 | |
| 625 | Nilmoney Bose ... | 1889 | |
| | G. Whyte ... | 1889 | |
| | T. A. Johnson ... | 1889 | |
| | Nirode Chander Mozomdar ... | 1889 | |
| | Hemadrish Chander Bhattacharjee. | 1889 | |
| 630 | Bhabani Charan ... | 1889 | |
| | E. Jewell ... | 1889 | |
| | A. Ben Court ... | 1889 | |
| | Albert Aukim ... | 1890 | |
| | Kalipodo Banerjee ... | 1890 | |

| | Names. | | Year. | |
|---|---|---|---|---|
| | 4th Grade Accountants—*concluded.* | | | |
| 635 | Behary Lall Koleh | ... | 1890 | |
| | Brij Behary Sett | ... | 1890 | |
| | Bipin Behary Dutt | ... | 1890 | |
| | Ujjal Chander Sen | ... | 1890 | |
| | Bata Krisna Ghose | ... | 1890 | |
| 640 | Nogendro Nath Mittra | ... | 1890 | |
| | Robert B. Smart | ... | 1890 | |
| | Arnold Roberts | ... | 1890 | |
| | Stephen Robert Ewing | ... | 1890 | |
| | Gourdas Roy | ... | 1890 | |
| 645 | Nando Coomar Ganguli | ... | 1891 | |
| | R. C. Chelliah | ... | 1891 | |
| | Deoki Nandan Sahai | ... | 1891 | |
| | Uma Churan Gupta | ... | 1891 | |
| | Adya Nath Sarkar | ... | 1891 | Passed under Appendix C, paragraphs 12 and 18, P. W. D. Code of 1886. |
| 650 | J. E. Rosario | ... | 1891 | |
| | Clifford L. Colthurst | .. | 1891 | |
| | Hem Chandra Ghose | ... | 1891 | |
| | Surendra Nath Guha | ... | 1891 | |
| | Haridas Tarafdar | ... | 1891 | |
| 655 | Haridas Mitra | ... | 1891 | |
| | A. S. Heberlet | ... | 1891 | |
| | Kali Das Mookerjee | ... | 1891 | |
| | Frank Elurja Pereira | ... | 1892 | |
| | Chuni Lal Banerji | ... | 1892 | |
| 660 | Sarat Chandra Chowdhury | ... | 1892 | |
| | Radha Kantha Paul | ... | 1892 | |
| | A. Ed. Texeira | ... | 1892 | |
| | Nando Gopal Mookherjee | ... | 1892 | |
| | Ekkari Lal Ghosh | ... | 1892 | |
| 665 | Sujan Nath Basak | ... | 1892 | |

# CIVIL ENGINEERING COLLEGE, SIBPUR.

## ANNUAL REPORT, 1891-92.

### ENGINEER DEPARTMENT.

| Classes. | Hindus. | Europeans and Eurasians. | Muhammadans. | Burmese. | Total. |
|---|---|---|---|---|---|
| 1st year ... | 41 | 4 | ... | ... | 45 |
| 2nd „ ... | 30 | ... | ... | 1 | 31 |
| 3rd „ ... | 11 | ... | ... | 1 | 12 |
| 4th „ ... | 9 | 2 | ... | ... | 11 |
| ... | ... | ... | ... | ... | |
| Total ... | 91 | 6 | | 2 | 99 |

The above table shows the number of students in the Engineer Department on 1st April 1891.

B.E. and L.E. examinations.

The University examination for B.E. and L.E. candidates began on 6th July. Out of the eleven students in the fourth-year class, eight were permitted to present themselves for this examination, four old students also came up for examination, bringing the total number of candidates up to twelve; of these one was absent, five passed, two for the degree of Bachelor and three as Licentiates in Engineering. Neglecting the absentee, the percentage of successful candidates was 45·45. This was considerably below the percentage of the previous year, when 78 per cent. passed. One reason for the falling off in the number who passed is that only one guaranteed appointment was open to competition; some of the better students, feeling that they were not likely to secure the appointment, elected to fail in order that they might compete again the following year, when two guaranteed appointments awaited the result of the examination. Of the five successful candidates, two passed in the first division and three in the second. The guaranteed appointment for the year was secured by G. Sedgley. All the five candidates are now undergoing a course of practical training under the Public Works Department. The Ambika Charan Chowdhuri Gold Medal was awarded to Gris Chandra Das, and the Trevor Silver Medal to Mohini Mohan Lahiri.

F.E. examination.

This examination was held at the Senate House on 4th May. Twelve candidates presented themselves for examination, of whom only four, or 33 per cent., passed. These four are now studying in the fourth-year class; five old

students rejoined this class, making a total of nine now preparing for the B.E. and L.E. Examinations to be held this year.

Annual examination.

The annual College examinations were held in May. Of the thirty-one second-year students twelve passed and were promoted to the third year. One old student has rejoined this class, so the total number in the third year is now thirteen.

Out of the forty-five first-year students, two left before the examination—one was sick and one was rejected at the test-examination; of the forty-one who presented themselves for examination, twenty-two, or fifty-three per cent., passed. They were promoted to the second year; thirteen failures rejoined this class, making a total of thirty-five, of whom two have since left; the present number in the second-year class is therefore thirty-three.

Admission.

Seventy-five applications for admission were received. Owing to the new rule regarding the percentages required in English and Mathematics a large number were rejected. Twenty-eight finally joined; of these two had passed the B.A., twenty-two the F.A., and only four the Entrance Examination of the Calcutta University. This is the first occasion on which such large percentage of young men admitted to the Engineer Department have passed the F.A. Examination, and it seems to indicate that the value of a technical education is beginning to be more appreciated. Another encouraging fact is that at the practical examination held in May 1891, the two first on the list were B.A's.; this shows that graduates of the Calcutta University are not above manual work; and now that there is a probability of a reduction in the length of the course being made by the University in favour of B.A's., we may expect them to join in greater numbers in future years.

In addition to the twenty-eight graduates and undergraduates, one outside student was admitted as a special case, twelve failures rejoined, making a total of forty-one. During the year nine have left, the number in the class is now therefore thirty-two.

The subjoined table shows the strength of this Department on the 31st March 1892:—

| Classes. | Hindus. | Europeans and Eurasians. | Muhammadans. | Burmese. | Total. |
|---|---|---|---|---|---|
| 1st year ... | 31 | 1 | ... | ... | 32 |
| 2nd ,, ... | 32 | 1 | ... | ... | 33 |
| 3rd ,, ... | 12 | ... | ... | 1 | 13 |
| 4th ,, ... | 8 | 1 | ... | ... | 9 |
| Total ... | 83 | 3 | ... | 1 | 87 |

against a total of 101 on 31st March 1891. This deficiency is partly due to fewer admissions to the first-year on account of the raising of standard for admission, and partly to the fact that several boys have been able to secure appointments before completing their College career.

## APPRENTICE DEPARTMENT.

The following table shows the strength of the Apprentice Department on 1st April 1891 :—

| Classes. | Hindus. | Europeans and Eurasians. | Muhammadans. | Total. |
|---|---|---|---|---|
| 1st year ... ... | 41 | 13 | ... | 54 |
| 2nd „ ... ... | 45 | 9 | 1 | 55 |
| 3rd „ ... ... | 24 | 1 | ... | 25 |
| 4th „ ... ... | 16 | 2 | ... | 18 |
| 5th „ ... ... | 14 | 2 | 1 | 17 |
| Total ... | 140 | 27 | 2 | 169 |

Final certificates.

Of the seventeen fifth-year apprentices, four left, before completing their full course, with appointments, nine left with the full certificate in February, and the remaining four are still in the College, their time of apprenticeship expiring in June. The two guaranteed appointments in the upper subordinate establishment, sanctioned by the Government of India, and appearing in the *Calcutta Gazette* of 12th August 1891, as Notification No. 287, fall to Bhola Nath De and Tara Pada Banerjee.

Final examination.

Eighteen fourth-year apprentices appeared at the Final Examination in July. Of these eleven passed, two failed in both class and shops, three failed in shops, and two in class work. Of those who passed, one has since left with an appointment, leaving ten in the shops completing their final course of practical training.

Annual examination.

The date for the annual examination was altered from January to July. Out of the twenty-five apprentices in the third-year class, one left with an appointment, and twenty-four presented themselves for examination. Of these ten passed, four failed in shops, and ten in class work. Three rejoined, so the total in the fourth-year is now thirteen.

Of the fifty-five apprentices in the second-year, thirty-three passed, eight failed in shops, and fourteen in class work, nine rejoined, and seven apprentices have since left; the present number in the class is therefore thirty-five.

The total number in the first-year class was fifty-seven, including three who rejoined the College in April and May. Of these four left, one was rusticated for leaving the College without leave, and one was expelled. Fifty-one therefore presented themselves for examination, and twenty-six passed, thirteen failed in shops, three in class work, and eight in both shops and class work. Twenty rejoined, one has since left, so the number in the second-year class is forty-five.

Admission examination.

Ninety-two names were registered for examination. Of these seventy-five only appeared at the examination, thirty of whom passed, and twenty-seven joined. In addition six were admitted as having passed the VIIth standard, six the Entrance examination of the Calcutta University, and one that examination in English and mathematics; twelve rejoined, bringing the total number in the first-year class to fifty-two. Two have since left, so the class now numbers fifty apprentices.

The following table shows the state of the Department on the 31st March 1892:—

| Classes. | Hindus. | Europeans and Eurasians. | Muhammadans. | Total. |
|---|---|---|---|---|
| 1st year ... ... | 43 | 7 | ... | 50 |
| 2nd „ ... ... | 36 | 8 | 1 | 45 |
| 3rd „ ... ... | 28 | 7 | ... | 35 |
| 4th „ ... ... | 13 | ... | ... | 13 |
| 5th „ (junior) ... | 9 | 1 | ... | 10 |
| 5th „ (senior) ... | 4 | ... | ... | 4 |
| Total ... | 133 | 23 | 1 | 157 |

The total on the 31st March 1891 was 169, so there has been a decrease of twelve in this Department.

Reduced fee and free list.

There are thirty-nine natives on the reduced fee list out of the sanctioned number of forty, so one vacancy is now available for award.

The free list for Europeans and Eurasians is full, but out of the twenty-five reduced feeships only 11 have been awarded. The continued falling off in the numbers of Europeans and Eurasians joining this Department is a question that needs enquiry, and will form the subject of a special reference.

Certificates.

In accordance with rules 10 and 11 of the Apprentice Department, two Overseers' and fourteen Sub-Overseers' certificates were granted to apprentices leaving the College before the completion of their apprenticeship.

Artisans.

The two Assamese artisans completed their time in the shops in February, and received the usual certificates. This class is now unrepresented, and requires special encouragement for its revival, as if efficiently trained it would supply useful economical workmen, capable also of supervising and instructing elementary technical classes. With the pronounced desire to establish technical schools, which is now manifested in Bengal, the encouragment of this class should form the subject of early and special attention.

Accountants.

An examination for admission to the fourth grade of Accountants, Public Works Department, was held on the 1st and 2nd June. Seventy names were registered, of whom sixty-two were present at the examination, thirteen passed and received the usual certificates.

Changes in staff.

The College suffered a severe loss in the death of its Principal, Mr. S. F. Downing. During his twenty-two years connection with the Engineering College, Mr. Downing had rendered himself familiar with the requirements of the Engineering profession in India, and his advice in the extensions now proposed will be much missed. His strict attention to details, and his unvarying desire to establish a thorough disciplinary system in Indian colleges should still bear fruit in the rules he made for maintaining discipline, and the benefits of his incumbency are felt and acknowledged by the students and apprentices, who have profited by his wise and impartial administration of the affairs of this College. The Professor of Engineering, Mr. Slater, was appointed to the Principalship, and his place was filled by the temporary transfer of Mr. B. Heaton from the Public Works Department. The proposal of Government regarding the filling up of the vacant Professorship of Engineering by the temporary transfer of an officer of the Public Works Department does not seem sufficient to secure that continuity in instruction which is so essential to the thorough training of the students; and in the interests of the College it is imperative that this continuity be established even at a slightly increased cost. This question, however, forms the subject of a separate communication, and need not therefore be further dealt with in this Report. Mr. Bartlett, Teacher of Drawing, returned during July from sick leave to Europe, and Babu Dwarka Nath Datta, who officiated for him, reverted to his substantive appointment as Teacher in the Apprentice Department, his *locum tenens*, Babu Radha Rahaman Guha, L.C.E., returning to his appointment in the Dacca Survey School. Babu Surendra Kumar Bose, B.C.E., Teacher in the Apprentice Department, was granted extraordinary leave without pay for three months from the 2nd January 1892, and Babu Hari Charan Mukerjee, L.E., was appointed to officiate for him. Babu Nobo Kumar Chakravarti, L.E., also a Teacher in the Apprentice Department, was granted extraordinary leave without pay from the 24th March 1892, and Babu Lalit Mohan Bysack, L.C.E., was appointed to act for him. These constant changes are much to be deplored, but they will continue to occur until the salaries offered are raised, as efficient teachers, who are also graduates in Engineering of the Calcutta University, can generally command higher salaries than are offered to them in this College. They only stay here until they can secure some more lucrative appointment. This practice should be stopped, either by binding the men down to the College, or else by making it worth their while to stay.

Buildings.

Partial repairs of the College buildings and servants' quarters were executed during the year. Sanction has lately been received to build a hospital, and it is hoped that the work will soon be started.

The hollows between the foreshore road and the College are nearly filled up, and provision has been made for draining that area. This should result in an improvement in the health of the students and residents. The buildings still required are, (*i*) an engineering laboratory, (*ii*) a physical laboratory, and (*iii*) a small observatory for instruction in practical astronomy.

Surveying.

The second and third-year Engineer classes went to Madhupur, on the East Indian Railway, in November for surveying. The third-year students were in camp from the 25th November till the 11th January, during which time they carried out the survey work necessary to enable them to prepare a project for a line of railway about six miles long. The second-year students went into camp on the 18th November, and remained there until the 27th January. They were engaged on an extensive trigonometrical and traverse survey, the details of which were filled in by a plane table: in addition to this they were occupied in levelling, contouring, and in the ordinary field operations. Some astronomical observations were also made, the true meridian was fixed, and a sun-dial was erected by the students from their own observations and calculations. The first-year Engineer students made a survey of the Botanical Gardens and ran several lines and circuits of levels, fixing and checking bench-marks.

The second, third, and fourth-year apprentice classes were instructed in chain, compass, plane table, and theodolite surveying, and also in levelling in the neighbourhood of the College.

Works visited.

The Principal visited the undermentioned works with the senior Engineer-students during the cold season:—

1. Messrs. Burn & Co's. shops (two visits).
2. Raniganj Pottery and Tile-works.
3. Barrakar Iron-works.
4. East Indian Railway Coal Mines at Giridih.
5. Jamalpur Workshops.
6. Messrs. Apcar & Co's Foundry.
7. Sibpur Jute Mills.
8. Hooghly Floating Bridge.
9. Barrackpore Water-works.

Mr. Heaton visited the Akra brick-field with the second, third and fourth-year Engineer-students. These visits to works are of great practical value to the students, and the more they can be extended the better. Under recent orders from Government the travelling expenses of the students are now paid, which is a great improvement on the old system, under which the students were required to pay their own expenses. These useful expeditions could be considerably extended with little increase in expenditure if a steam-launch were attached to the College. The banks of the Hooghly are lined with various manufacturing industries, which without a launch are inaccessible to the bulk of the students, as large classes cannot be transported by land.

The launch would be useful in various other ways, such as bringing water for drinking and culinary purposes, and when not thus in use could be employed to keep up rapid communication with Calcutta. The launch might either be transferred from one of the Public Works Divisions, or probably a spare one could by obtained from the Government Dockyard. If neither of these alternatives for the supply are available, the launch might be made in the Sibpur Workshops, or at

the Dockyard. The want has been long felt, and would be a distinct economic addition to the College, and would bring it into closer touch with Calcutta.

Models. The models referred to in last year's report have arrived from England. In addition to these several models were purchased or presented to the College. Messrs. Burn & Co., with great liberality, presented the College with a complete set of samples of their pottery and tile-work, as manufactured at Raniganj, together with specimens of the raw materials used for different classes of work. A lever-testing machine was purchased from the East Indian Railway, and will be a great help in showing the students how some of the physical constants used in engineering are arrived at. It is not a very powerful machine, but will supply a distinct want until Government can equip a suitable engineering laboratory for the College. A fitter has been sanctioned for the model-room, and is now busily engaged in repairing and putting into working order the various old models that have been lying by for years unused. The model-room has been fitted with shelves and glass cases, and a descriptive catalogue is in course of preparation.

Photography. The small room in which the models used to be kept is now converted into a dark room for photography. Mr. Heaton, who is an amateur photographer of considerable skill, has spent much time and thought over the arrangements, and it is hoped that enlargements, to serve as lecture diagrams, will soon be turned out. The College is now practically unsupplied with lecture-diagrams, and almost all work of a descriptive character has to be drawn by hand on the black-board, so that these diagrams will be of great service in instruction, and a special grant will be applied for to defray the cost of producing these diagrams if the present arrangements are successful and economical.

Conduct. The conduct of the students during the year has been very fair, and no flagrant breaches of discipline occurred. The only case of expulsion was an Eurasian boy who left College against orders.

Athletics. During the year a pavilion was erected at the south-east corner of the cricket-ground. The hollow along the eastern side of the cricket field has been recently raised, and the ground is consequently much improved. Cricket and football are more popular than ever, and in the case of football it will soon be necessary to lay out other goals for the game, the present ground not being large enough for the numbers who turn out every evening to play. Government helped the club with a grant this year of Rs. 400, which has been partly spent in improving the cricket-ground: the balance will be required for laying out and keeping in order new practice pitches, and purchasing nets to enable a larger number to practise than can do so at present.

Challenge. The College was beaten at cricket by the Medical College for the Harrison Shield, but in all other matches it was victorious. Three native students were prominent members of the College eleven.

The gymnasium is not much used. Being situated in the open, the bars are affected by alternate moisture and heat, and are apt to crack and produce splinters on the surface. It would be desirable to place the gymnasium in an open shed under cover. A gymnastic instructor is also required, and a course of gymnastics ought to be made compulsory, marks for attendance and proficiency being awarded which should be carried to the annual and final examinations. A proposal of this nature has already been submitted officially for approval.

The annual sports were held on the 12th February, the President of the Club, Mr. Macdonell, being kind enough to make all arrangements. This event is now eagerly looked forward to by the students, and the day is not far distant when the natives will actually go into training for them. The events this year were open alike to natives and Europeans. Out of the thirty-one prizes awarded sixteen were won by natives; this result confirms the opinion formed last year that the natives were able to hold their own in competition with the Europeans and Eurasians.

At open sports for natives held in Dalhousie Square, a team from this College won the tug-of-war, and gained the prize in Swiss Drill. In most of the other events the Sibpur students won one or more prizes, and the College may now be said to have secured a position in athletics. This superiority is probably due to their physical improvement from daily exercise on the play-ground, coupled with the healthy occupation they have in the shops.

Health. A report by the Resident Medical Officer on the health of the College during the year under review is annexed as Appendix A. There appears to have been a slight increase in the daily average of students on the sick list as compared with last year. The average daily number excused from class on account of sickness was 5·81; as the daily average attendance was two hundred and thirty-four, there were 2·48 per cent. sick daily, against 2·38 in the previous year.

One case of cholera occurred amongst the students in the cold weather, which, however, did not terminate fatally.

Volunteers. The number of men in the volunteer corps on the 31st March was forty-one. Of these thirty-four were extra efficients against twenty-one last year. The figure of merit of the corps was 46 34 per cent. As the musketry rules have been altered this year, as also the method of making up averages, it is not possible to compare the present year's figures with those for previous years. The rifle range was opened early in the drill season, and has been used a good deal for practice in addition to class-firing. Mr. Macdonell was appointed Second Lieutenant, *vice* Second Lieutenant Küchler transferred to the supernumerary list.

Library. Ninety-four books were added to the Library; seventy being purchased and twenty-four presented to the Library.

Workshops. The students and apprentices attended shops daily as usual. Mr. J. H. Toogood continued to be in charge of the shops during the year. Rupees 12,000, sanctioned from educational funds, were spent in the purchase of machines, and

good work is now being done by the students. A detailed report will be submitted by the Executive Engineer through the usual channel.

Board of Visitors. The Board of Visitors met once during the year to transact the business that was brough before it.

J. S. SLATER,
*Principal.*

*The 23rd April* 1892.

# ANNUAL SPORTS.

## ATHLETIC CLUB.

*12th February* 1892.

| | *Prize winners.* |
|---|---|
| No. 1.—*Long Jump* ... | 1. J. Parsons.<br>2. K. G. Sarma. |
| „ 2.—*Hurdle Race* ... ... | 1. S. C. Guha.<br>2. A. C. Guha.<br>3. M. K. Bose. |
| „ 3.—*High Jump* ... ... | 1. W. Viney.<br>2. B. B. Ray. |
| „ 4.—*One hundred yards Flat Race* ... | 1. R. Aguilar.<br>2. M. K. Bose.<br>3. D. P. Bose. |
| „ 5.—*Throwing the Cricket Ball* ... | M K. Bose. |
| „ 6.—*One hundred and fifty yards Handicap* ... ... | 1. S. C. Guha.<br>2. Not awarded.<br>3. A. Chater. |
| „ 7.—*Putting the Shot* . .. | J. Parsons. |
| „ 8.—*Quarter mile Race* ... ... | 1. J. Parsons.<br>2. R. Young.<br>3. R. Aguilar. |
| „ 9.—*Sack Race* ... .. | 1. S. N. Bose<br>2. J. Goodwin. |
| „ 10.—*Three-legged Race* ... ... | 1. P. C. Gogoi.<br>S. C. Ghose.<br>2. J. Wise.<br>A. Wilson. |
| „ 11.—*Obstacle Race* ... ... | 1. R. Aguilar.<br>2. A. Chater. |
| „ 12.—*Tug-of-War*—Challenge Cup—Engineers *versus* Apprentices | Won by Apprentices. |
| „ 13.—*Lance* versus *Bucket* ... ... | 1. H. Woodward and Lathwood.<br>2. R. M. Das and M C. Das |
| „ 14.—*Greasy Pole* ... ... | A. C. Guha. |
| „ 15.—*Consolation Race* ... ... | B K. Ray. |



W. J.—Reg. No. 1605J—150—27-5-93.